OIL, GAS & PETROCHEMICAL PROCESSING

Petroleum Refiner

MAY
1958

YOUR REPORT ON API PAPERS

How to Design a New Smokeless Flare 148

Gasoline from a Liquid Poly Catalyst 173

New Inhibitor Controls DEA Corrosion 183

Piping Design Stops Pulsating Flow 185

ELECTRODE KNOW-HOW

Successful Welding for Maintenance 207

COMPLETE HANDBOOK

Foundation Design of Stacks & Towers opp. 238

CURRENT PROBLEM

What It Takes To Bargain with Labor 282

For a "Quick Look" at this issue, turn the page . . .

SUBSCRIPTION PRICE $2 PER YEAR
SINGLE COPY PRICE 50 CENTS

POSITIVE CONTROL OF MATERIALS IN MOTION B-I-F

At McColl-Frontenac's
East Edmonton Refinery . . .

FAIL-SAFE LUBE OIL BLENDER Increases Production, Reduces Costs!

Faster, more accurate product formulation keyed directly to market demands, pay-out proven performance, and a 50% reduction in process tankage requirements . . . these were the vital considerations which moved McColl-Frontenac to select a Proportioneers LUBE OIL BLENDER for its new Edmonton Plant. This blender provides the versatility required to produce over 3,000,000 gallons per year of *fast-moving* oils for the company's western Canada market.

The *unitized construction* of the Proportioneers blender permits future expansion at minimum cost. Built-in totalizers continuously give performance and inventory checks . . . a *memory feature* inherent in the mechanical brain which controls the blending operation, ensures correct end product at all times . . . and total output can be quickly adjusted to suit production requirements without affecting formulation accuracy.

For more lucrative lube blending, request Bulletin SM-2055.
Write **Proportioneers, Inc., 412 Harris Ave., Providence 1, R. I.**

PROPORTIONEERS
DIVISION OF
B-I-F INDUSTRIES B-I-F METERS FEEDERS CONTROLS

Volume 37, No. 5 May, 1958

API SECTION

How to Design a Smokeless Flare 148
P. D. Miller and H. J. Hibshman
How Shell Treats Refinery Waste 153
G. J. Reno, E. D. Neumann and L. C. Burroughs
Hydrogen Improves Cat Cracker Feed 161
M. D. Abbott, R. C. Archibald and R. W. Dorn
Process Feed for More Cat Gasoline 167
W. V. Medlin, J. C. Ornea and A. J. Johnson
Gasoline from a Liquid Poly Catalyst 173
E. D. Kane and G. E. Langlois
How Phillips Solved Six Gas Plant Corrosion Problems 177
J. S. Connors and C. L. Seyer
Lab Inhibitor Stops DEA Corrosion 183
J. D. Sudbury, O. L. Riggs and J. F. Leterle
Piping Design Stops Pulsating Flow 185
Ralph James
How Do Mixtures Affect Knock Ratings? 191
Eric J. Y. Scott
Carbon Steel Brittle at Ambient Temperature . . 201
F. B. Hamel
Trouble-Shooting Delayed-Coking Units 202
N. A. Weil and F. S. Rapasky
New Test for Sediment 204

OTHER TECHNICAL FEATURES

Successful Welding for Maintenance 207
Ray M. Kolb
Treat Wastes With Dissolved Air 211
William I. Katz
Now Separate by Membrane Permeation 214
Robert C. Binning and Frank E. James
Relative Volatility Method for Distillation Calculations 216
Francis W. Winn
What's New in Fractionator Control 219
T. C. Wherry and D. E. Berger
Estimate Cost of Compression Plants 225
I. Bromberg
Applied Hydrocarbon Thermodynamics, Part 5 . 227
Wayne C. Edmister and William S. Hanna
Know Your Asphalts (Part 9) 234
E. J. Barth
Now—Ammonia by Automation 235
S. Bresler
The Design of Foundations for Stacks and Towers . . . . . Opposite 238
V. O. Marshall

As Management Sees It . . .

Human Relations Can Be Dangerous 277
What It Takes to Bargain With Labor 282
H. R. Shepherd
Learn to Recognize and Manage Problem Workers 292
Dr. John J. Thorpe

DEPARTMENTS

LOOK BOX, Featuring . . .
You "Oughta" Build Now 133
Mail Box 124
Quick Look at Industry . . 4
Valuable Reading Ahead 240
How To Do It 244
Who's Building 255
Reviewing New Books . . 242
If Oil Could Speak 309
What's Happening 311
Meetings Calendar 331
Men In Industry 334
Suppliers Notes 358
Classified Advertising . . . 372
New Equipment 374
Manufacturers Literature 374
Index to Advertisers . . . 392
Readers Service Card . . . 393

Petroleum Refiner
OIL, GAS AND PETROCHEMICAL PROCESSING

A Quick Look at This Issue

These handy digests permit checking the articles you want to read first. ☑

API SECTION

☐ **How to Design a New Smokeless Flare . . .** Here are complete design details of a new type of smokeless flare. One installation has been in service for more than a year and has provided completely smokeless and noiseless burning. Several others are being designed. To adapt this economical solution to your flaring problems, study carefully this article starting on **Page 148.**

☐ **How Shell Treats Refinery Wastes . . .** In successfully meeting the Washington state pollution requirements, Shell separated all refinery wastes into four sewer systems. Oil removal, biological treatment and retention have reduced the objectional sulfides and phenols to well within the required limits. For the complete story, turn to **Page 153.**

☐ **Hydrogen Improves Cat Cracker Feed . . .** Hydrogenation not only reduces the sulfur and nitrogen content of catalytic cracker feed, but it also gives some desirable conversion of hydrocarbons. Here is the story of what happens during hydrogenation and how subsequent cracking is improved. **Page 161.**

☐ **Process Feed for More Cat Gasoline . . .** Catalytic cracking is an important refining tool for the producton of increasing quantities of gasoline. There are a number of processes available for recovering a greater percentage of crude oil for cracking feedstock. Examine this comparison of some feed preparation methods. **Page 167.**

☐ **Gasoline from a Liquid Poly Catalyst . . .** Equipment is available now to use liquid phosphoric acid to polymerize propylene or mixed propylene-butylene feeds. Here is the story on how this new process works. **Page 173.**

☐ **Six Gas Plant Corrosion Problems . . .** Phillips presents the solutions to six commonly occuring corrosion spots. These case histories can be used to solve your gasoline plant, refinery, and petrochemical plant problems. For complete details, turn to **Page 177.**

Please Turn Page →

A Quick Look at This Issue . . .

☐ **Lab Inhibitor Stops DEA Corrosion . . .** Corrosion studies of alkanolamine systems reveal a peculiar type of thread-like corrosion. It's called filiform corrosion. Conoco developed an inhibitor, labeled T-52, which controls this type of corrosion in laboratory tests and in preliminary field studies. For complete details, turn to **Page 183.**

☐ **Piping Design Stops Pulsating Flow . . .** Reciprocating compressor piping requires special design considerations. Analog computers can be used as a special piping design tool which will not only size the piping but will also predict the performance to be expected from the compressor. For complete details, turn to **Page 185.**

☐ **How Do Mixtures Affect Knock Ratings? . . .** Studies reveal how hydrocarbon types influence the knocking tendencies of blends. These data help formulate a model to predict the interaction among gasoline components. For calculating your next gasoline blend, remember these principles. **Page 191.**

☐ **Carbon Steel Brittle At Ambient Temp . . .** A total of 161 random samples of vessel steels show conclusively that ordinary vessel steel can be brittle at all ambient temperatures. A temperature of 100 F., or higher, is required before the danger of a "low temperature" brittle failure becomes negligible. For complete details, turn to **Page 201.**

☐ **Trouble-Shooting Delayed-Coking Units . . .** A survey of 16 units revealed the most frequently encountered difficulties. The authors have studied these problems and present recommendations to remedy these troubles. For complete details, turn to **Page 202.**

☐ **Successful Welding for Maintenance . . .** Have you ever tried to weld where the composition of the base metal was unknown? This article tells how to determine different kinds of base metal, then shows you how to select the proper electrode for welding. For complete details, turn to **Page 207.**

☐ **Treat Wastes With Dissolved Air . . .** Dissolved-air flotation coupled with chemical flocculation supplements gravity separation in refinery waste treatment. Three advantages are: less holding time, consistent results, and lower chemical dosages. Study this, then review your waste treatment method. Turn to **Page 211.**

☐ **Now Separate by Membrane Permeation . . .** This process splits components on the basis of their solubility in a polymer membrane. In some cases the separation is easier and cheaper than by more conventional methods. You will want to consider this approach for those hard-to-make product splits. **Page 214.**

☐ **New Relative Volatility Method for Distillation Calculations . . .** is especially suited for minimum tray calculations. This is another from the distillation expert Francis Winn, and he shows you how to get more accurate calculations; you'll like this modification . . . see **Page 216.**

☐ **What's New in Fractionator Control? . . .** Here's how Phillips designed analytical controls for a depropanizer, debutanizer and deisobutanizer. They found that these instruments give performance unobtainable by conventional methods. Turn to **Page 219.**

☐ **Estimate Cost of Compression Plants . . .** Here is a break-down of what you can expect to pay for a compressor station. Data are given for five types of plants and a range of sizes from 200 to 3,000 brake horsepower. Turn to **Page 225.**

☐ **Applied Hydrocarbon Thermodynamics (Part 5) . . . Thermal Expansion Factors of Petroleum Liquid . . .** If you're not familiar with the improved Jessup Modulus Method for thermal expansion calculations of liquids, you'll want to read this one immediately. You'll like the easy way these charts are used and you'll clip them for your files. Take a quick look at **Page 227.**

☐ **Now—Ammonia by Automation . . .** Ammonia can be made more efficiently by complete automation. Here's the type of controls and their control points in this first completely automatic ammonia plant in Japan. The function and simplicity of this system can help you in modifying your plant. Turn to **Page 235.**

☐ **The Design of Foundations For Stacks and Towers . . .** This article, originally published in the August, 1943 issue of PETROLEUM REFINER, was so popular and complete on the subject of foundation design, that all reprints have long been distributed and still the demand continues. Therefore, it is again presented in its revised version, complete and unabridged. Opposite **Page 238.**

☐ **Human Relations Can Be Dangerous . . .** There is no such thing as a "one shot" formula to success in refinery human relations. However, many personnel departments are giving this idea a serious try. For three of the most common human relations "fantasies" in use today, plus logical cures of each, be sure you turn to **Page 277.**

☐ **What It Takes to Bargain With Labor . . .** Successful negotiations of labor contracts require a great deal of tact and skill on the part of the Management team. Irrespective of a Union committee's attitude, its tactics, or any demands it may make, Management must be fair and honest—yet it cannot afford to be bluffed. Management personnel must, therefore, enter the negotiations confidently and well prepared. This article tells them how to go about it. Turn to **Page 282.**

☐ **How To Handle Refinery Problem Workers . . .** Persistent drinkers, chronic absentees and several other types of workers have adverse effects on the morale of fellow employes. Here's how you can recognize and handle these problem cases. Turn to **Page 292.**

Petroleum Refiner

RAY L. DUDLEY, Founder, 1891-1957

WILLIAM G. DUDLEY.....Publisher
TOM W. NELSON.....General Manager
R. M. DE SOMBRE.....Assistant General Manager
SILAS B. RAGSDALE.....Editorial Director
DR. JOHN J. McKETTA, JR.....Chairman of Editorial Committee
GEORGE B. GIBBS.....Editor
FRANK L. EVANS, JR.....Maintenance and Design Editor
HAROLD L. HOFFMAN.....Process and Construction Editor
THOMAS C. PONDER.....Petrochemicals Editor
CLAYTON A. UMBACH, JR.....Management and Personnel Editor
HARRISON T. BRUNDAGE.....Eastern Editor
GILBERT M. WILSON.....Western Editor
DR. LEWIS F. HATCH.....Contributing Editor
WALLACE FITZGERALD.....Managing Editor
JACK COCKERHAM.....Presentation Editor
CHARLES VERVALIN.....Editorial Assistant
KATHERYNE BAST.....Editorial Assistant
EUNICE OKONESKI.....Librarian

ADVERTISING

HOUSTON 19: Jack Walker, 3301 Buffalo Drive, Phone JAckson 9-4301; NEW YORK 17: Gene Hart, George Skelton, 250 Park Ave., Phone YU 6-6558; CLEVELAND 16: Harvey Dunn, Bill Westfall, 20800 Center Ridge Rd., Phone EDison 3-1650; CHICAGO 4: Martin Halloran, H. G. Fitzpatrick, 332 S. Michigan Ave., Phone Wabash 2-9330; LOS ANGELES: Jay Carte, W. W. Wilson Bldg., Huntington Park, Phone LUdlow 7-1219; TULSA 3: Jim Isaacks, 916 Enterprise Bldg., Phone CH 2-9211; DALLAS 2: Ed Thompson, 518 Second Unit Santa Fe Bldg., Phone Riverside 7-7344. EUROPEAN: Theodor Miocha, Agent, Limmerstrasse 31, Hannover, Germany, Phone 42935. UNITED KINGDOM: Frank Chambers, Agent, 120 Moorgate, London E.C.2, Phone Monarch 5661. Advertising rates on application. Cable address: GULFPUBCO, Houston.

SUBSCRIPTIONS

T. A. Gaden, Subscription Manager, P. O. Box 2608, Houston 1, Texas. U.S.A. Single copies 50 cents (except special issues) for domestic and foreign. Double price for copies over one year old. Subscription rates—both foreign and domestic $2 a year. Subscriptions restricted to those engaged in refining, natural gasoline or petrochemical industries or service and supply company personnel connected thereto. PETROLEUM REFINER, published on the 12th of each month, entered as second class matter June 16, 1923, at the post office at Houston, Texas, under act of March 3, 1879. Copyright 1958 by The Gulf Publishing Company.

Postmaster: Send notification (Form 3579) regarding undeliverable magazines to Petroleum Refiner, Box 2608, Houston 1, Texas.

Specialized Oil Publications of
THE GULF PUBLISHING COMPANY
Box 2608, Houston (1), Texas

PETROLEUM REFINER and The REFINERY CATALOG for the oil, gas and petrochemical processing industry.

WORLD OIL (formerly The Oil Weekly) and The COMPOSITE CATALOG for the drilling-producing industry.

PIPE LINE INDUSTRY and The PIPE LINE COMPOSITE CATALOG for the oil and gas pipe line industry.

Petroleum Refiner is indexed by Industrial Arts Index, Chemical Abstracts and by Engineering Index, Inc. Microfilm copies available through University Microfilms, Ann Arbor, Michigan.

Foundations' Man

WE TOLD YOU last month about May's special feature, "Foundations for Stacks and Towers" and how we are repeating it for the third time because of an apparent never-ending demand. Well, here's the author of that gem, which you will find opposite Page 238. V. O. Marshall has been a project engineer for Tennessee Eastman Co., Kingsport, Tenn. for the past 13 years. Here he supervises engineering for plant expansion projects and also supervises pressure vessel practices for the entire plant. Marshall's initial job, 1921-30, was with Mt. Vernon Car Manufacturing Co., Mt. Vernon, Ill., as draftsman and job engineer. When he wrote "Foundations," which PR first published in 1938, he was a designer, project engineer and finally chief engineer with J. P. Devine Manufacturing Co. in Mt. Vernon. His professional affiliations include ASME, Tennessee Society of Professional Engineers and the National Society of Professional Engineers.

Form Wins Again

EXPERIENCED race track habituees think long before they abandon the form sheet when placing their bets. They want to see "the record" because one usually can find no better gage of the future than what a horse—or a magazine—has done in the immediate past.

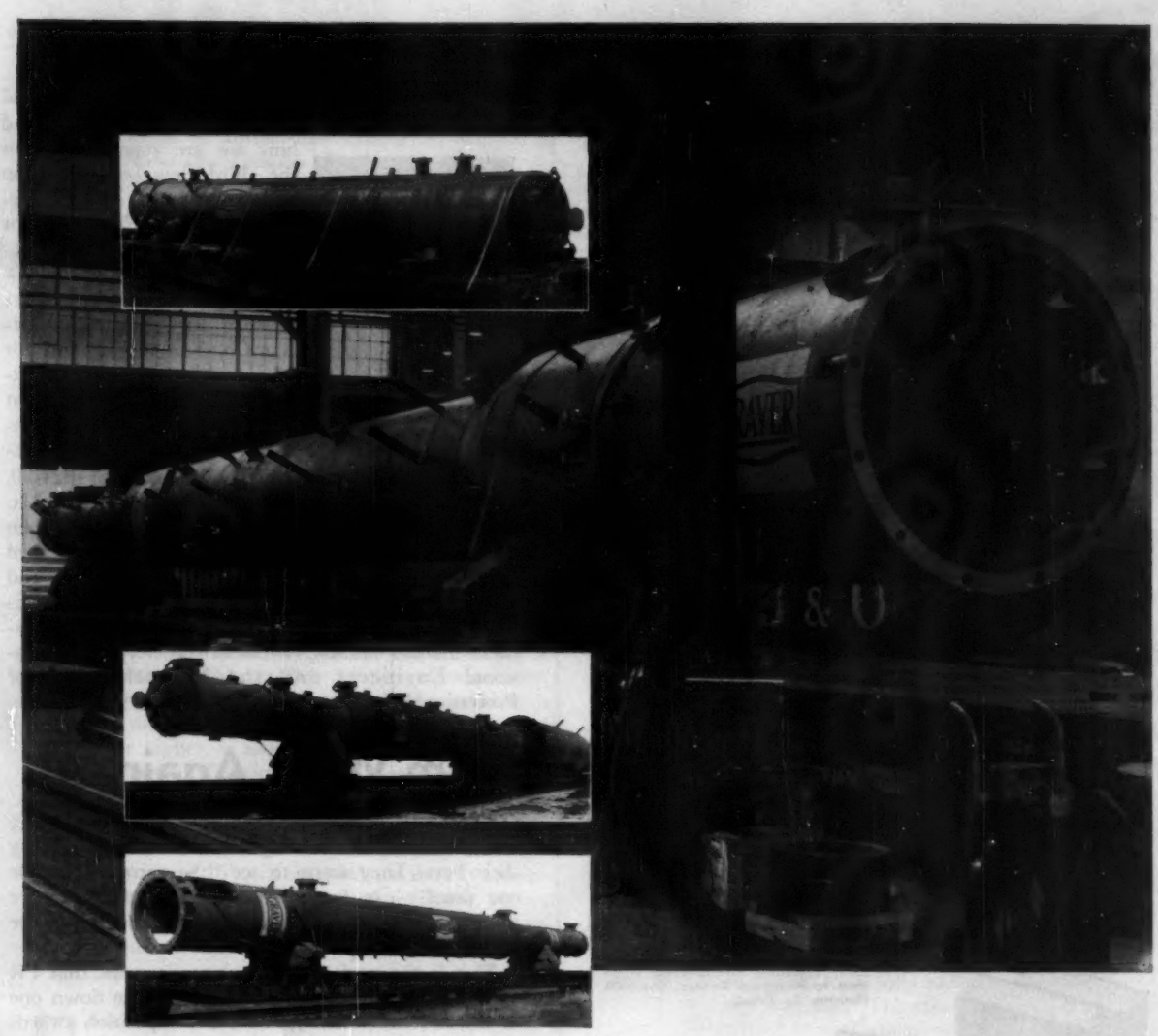
This is the preface to an announcement that PR has, for the second successive year, taken down one of the Fourth Annual Jesse Neal Competition awards for editorial achievement. The specific job was Don Lambert's *Disaster Planning* Special Report which appeared in our December issue. Don's series on oil industry public relations also got a prize, you might remember, in the Jesse Neal 1956 competition.

So "on form", it appears that PR continues to lead the entire list of entries. Or did we have to tell you that the $2 it costs for a year's subscription is just about as safe a bet as one can make?

Keep Oil Speaking

A WHILE BACK with no show of modesty we bragged on our "If Oil Could Speak" series which has been running in PR now for more than a year. If we had waited, we could have had Shell's Tom H. Hurley of Midland, Texas, do the bragging for us. His letter:

"Your articles, 'If Oil Could Speak' should be in the hands of every oil industry employe. My copies are circulated and thus have eventually become lost or misplaced. I'm sure it would be appreciated by the industry if reprints were made available for distribution."



260 TONS OF TOWERS AND REFINING VESSELS FOR

Pure Oil's Catalytic Reformer at Lemont, Ill.

The big new catalytic reforming unit for Pure Oil Co., at Lemont, Illinois, contains a number of units fabricated by Graver. Designed and built by The M. W. Kellogg Company, the reforming unit has a capacity of 12,000 barrels a day. It is a combination unit which desulfurizes 18,000 bpsd of feed stocks and converts low octane naphtha into high octane gasoline. For this unit Graver supplied a fractionator, debutanizer, absorber, accumulator, straight-run stabilizer and tail-gas absorber. Such orders show the confidence placed in Graver's long experience in fabricating all types of processing equipment for the petroleum, chemical and petrochemical industries. Nationwide facilities enable Graver to handle single-unit, multiple-unit and repeat orders with expertness and dispatch.

GRAVER

Building for the Future on a Century of Craftsmanship in Steels and Alloys

GRAVER TANK & MFG. CO., INC.

EAST CHICAGO, INDIANA • New York • Philadelphia
Edge Moor, Delaware • Pittsburgh • Atlanta • Detroit • Chicago
Tulsa • Sand Springs, Oklahoma • Houston • New Orleans
Los Angeles • Fontana, California • San Francisco

For more data on advertised products, use Readers' Service Cards, last page.

"Oilwell" Bull Plugs and Swaged Nipples

and secure quality that is safe to use in restricted areas

For restricted areas in refineries and petrochemical plants . . . are you as particular about the specifications of your bull plugs and swaged nipples as you are about the piping with which they are used? Sizes 2" and under in "Oilwell" bull plugs and swaged nipples are machined from AISI-1015 special bar quality of open hearth steel. We do not use screw stock or high carbon steels, which would not make reliable fittings for hazardous refinery operations.

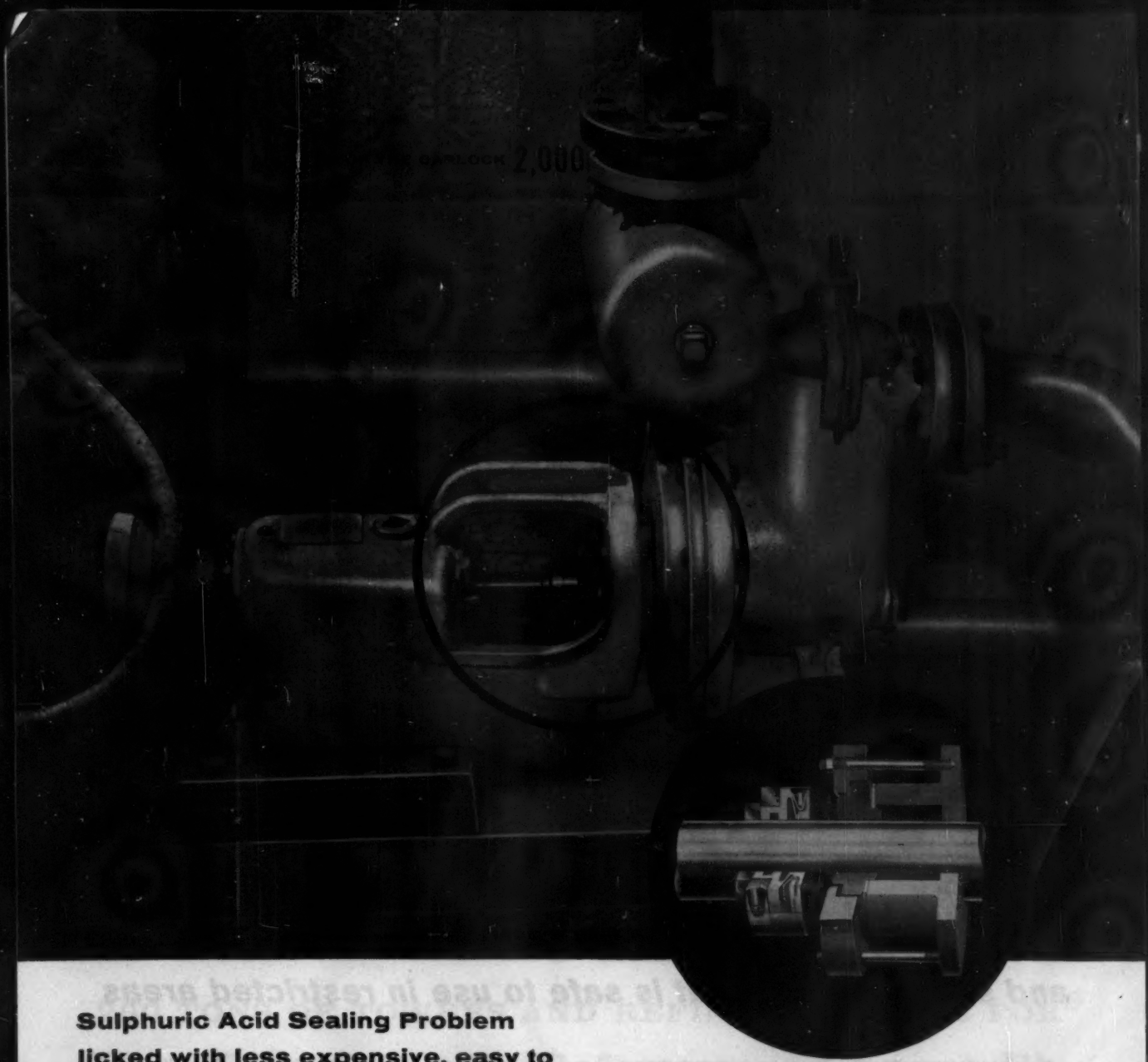
Larger sizes for non-restricted production and pipe line applications . . . are manufactured from seamless steel pipe; and all casing, tubing and line-pipe threading conforms to API standards.

"Oilwell" stores carry large stocks of these better bull plugs and swaged nipples . . . standard, extra heavy and double extra heavy. And if you require an unusually large quantity or sizes not commonly stocked, your "Oilwell" representative can arrange for quick delivery.

"OILWELL"
REG. U.S. PAT. OFF.

Oil Well Supply Division of USS United States Steel

Branches Serving All Oil Fields Executive Offices—Dallas, Texas Area Offices—Calgary, Alberta · Casper, Wyoming · Columbus, O. Dallas, Texas · Houston, Texas · Tulsa, Okla. · Los Angeles, Calif. Export Office—30 Rockefeller Plaza, New York 20, N. Y.



Sulphuric Acid Sealing Problem licked with less expensive, easy to install *Garlock Mechanical Seal*

Garlock CHEMISEAL Mechanical Seal used on pumps at Continental Oil Co. has TEFLON bellows, a TEFLON-filled carbon sealing face, and ceramic stationary seat.

In April 1955, Continental Oil Co., Chicago installed a standard Garlock CHEMISEAL* on a centrifugal pump handling 101.6% and 78-80% sulfuric acid for one-fourth the cost of the previous seal. This outside seal was reported easy to install by regular maintenance personnel. The service life is 8 to 10 months compared to 8 days for soft packing.

Now all centrifugal pumps in this service at Continental are equipped with Garlock CHEMISEAL Mechanical Seals. They handle up to 100,000 lbs. per day of sulfuric acid at temperatures to 135° F.

Garlock CHEMISEALS can solve your difficult sealing jobs too. Ask your Garlock representative for his recommendation. He can choose from "The Garlock 2,000" . . . two thousand different styles of packings, gaskets, and seals for every need. Or write for CHEMISEAL Folder AD-164.

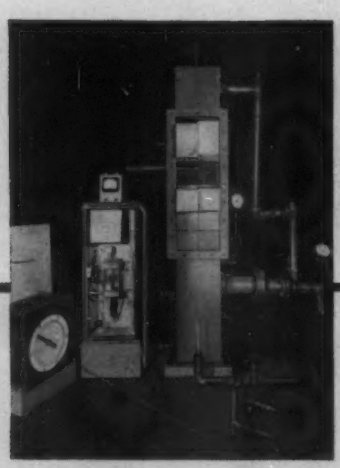
*Registered Trademark

THE GARLOCK PACKING COMPANY, Palmyra, New York

For Prompt Service, contact one of our 30 sales offices and warehouses throughout the U. S. and Canada.

GARLOCK

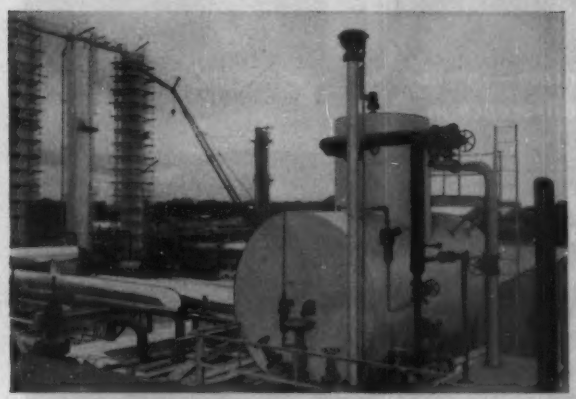
Packings, Gaskets, Oil Seals, Mechanical Seals, Molded and Extruded Rubber, Plastic Products



Pilot tray-type deaerator shown with continuous oxygen analyzer in test setup.

ALLIS-CHALMERS DEAERATORS

Looking for more effective deaeration?



Outdoor installation of Allis-Chalmers deaerator in southern chemical plant.

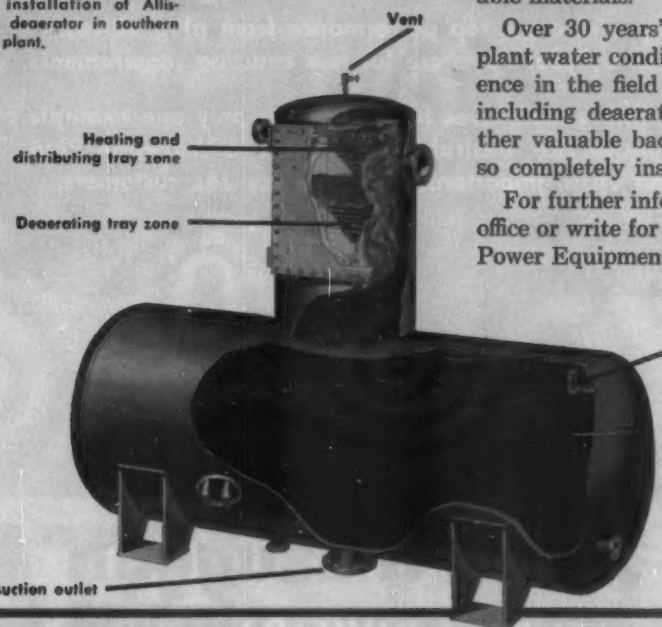
● If so — you'll be interested in the continuing research program at Allis-Chalmers to evaluate all factors in the design of deaerators.

This program includes the use of a specially built pilot deaerator with automatic oxygen analyzer and recorder. Operating factors and deaerating compartment design can be varied to study length of spilling edge of trays, heating area and method of flow. Results obtained with this setup are quickly translated into deaerators designed for optimum performance.

In addition to this continuous testing, metallurgical research is being done to select the most suitable materials.

Over 30 years' experience in the field of power plant water conditioning, and over 75 years' experience in the field of steam power plant equipment including deaerating-type condensers, provide further valuable background. No other manufacturer so completely insures deaerator performance.

For further information contact your nearby A-C office or write for Bulletin 28B8853, Allis-Chalmers, Power Equipment Division, Milwaukee 1, Wis.



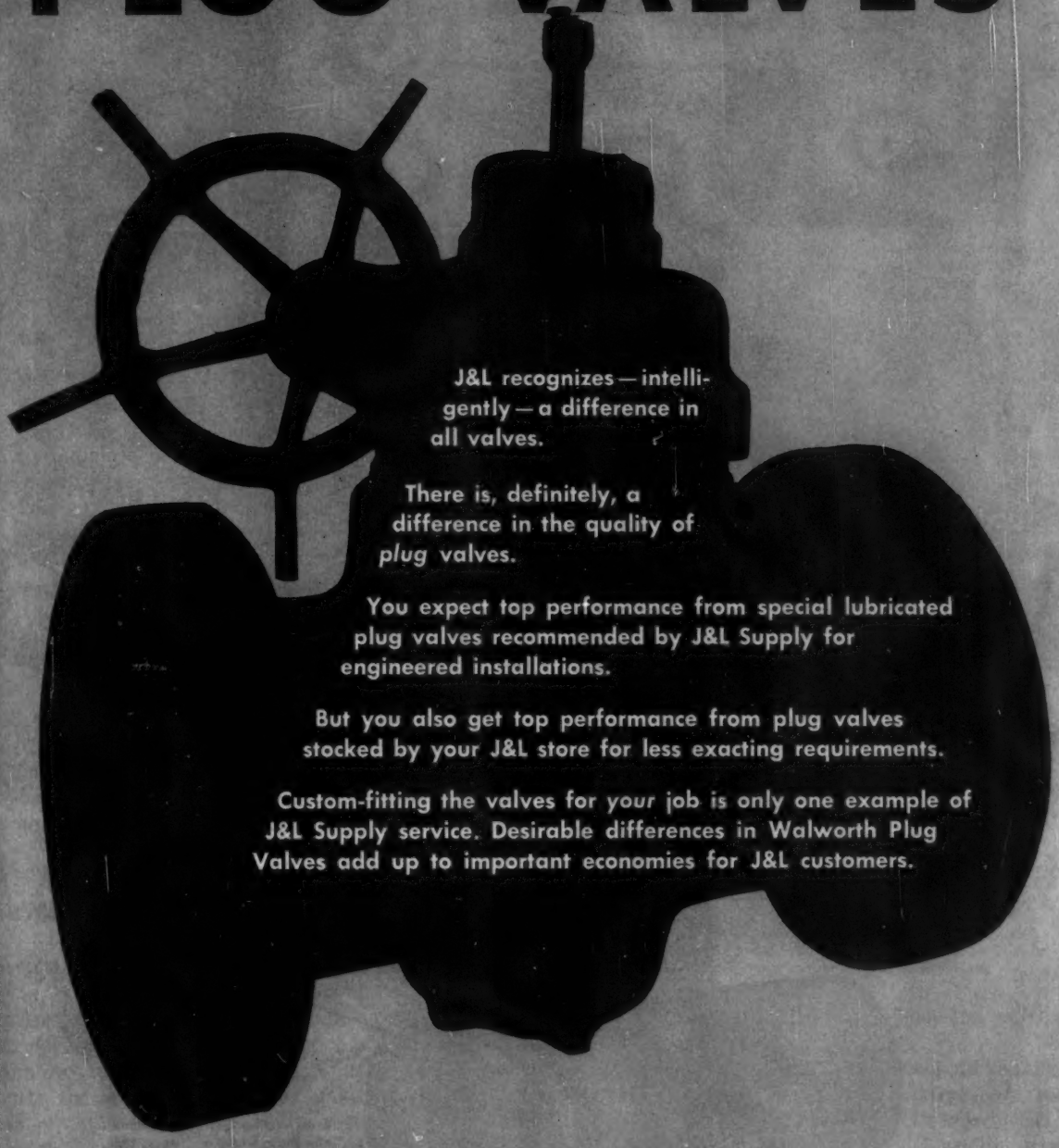
Cross section of tray-type deaerator shows water and steam flow.

ALLIS-CHALMERS

A-5674

For more data on advertised products, use Readers' Service Cards, last page.

J & L recognizes a difference in PLUG VALVES



J&L recognizes—intelligently—a difference in all valves.

There is, definitely, a difference in the quality of *plug* valves.

You expect top performance from special lubricated plug valves recommended by J&L Supply for engineered installations.

But you also get top performance from plug valves stocked by your J&L store for less exacting requirements.

Custom-fitting the valves for *your* job is only one example of J&L Supply service. Desirable differences in Walworth Plug Valves add up to important economies for J&L customers.

Jones & Laughlin

SUPPLY DIVISION—Tulsa

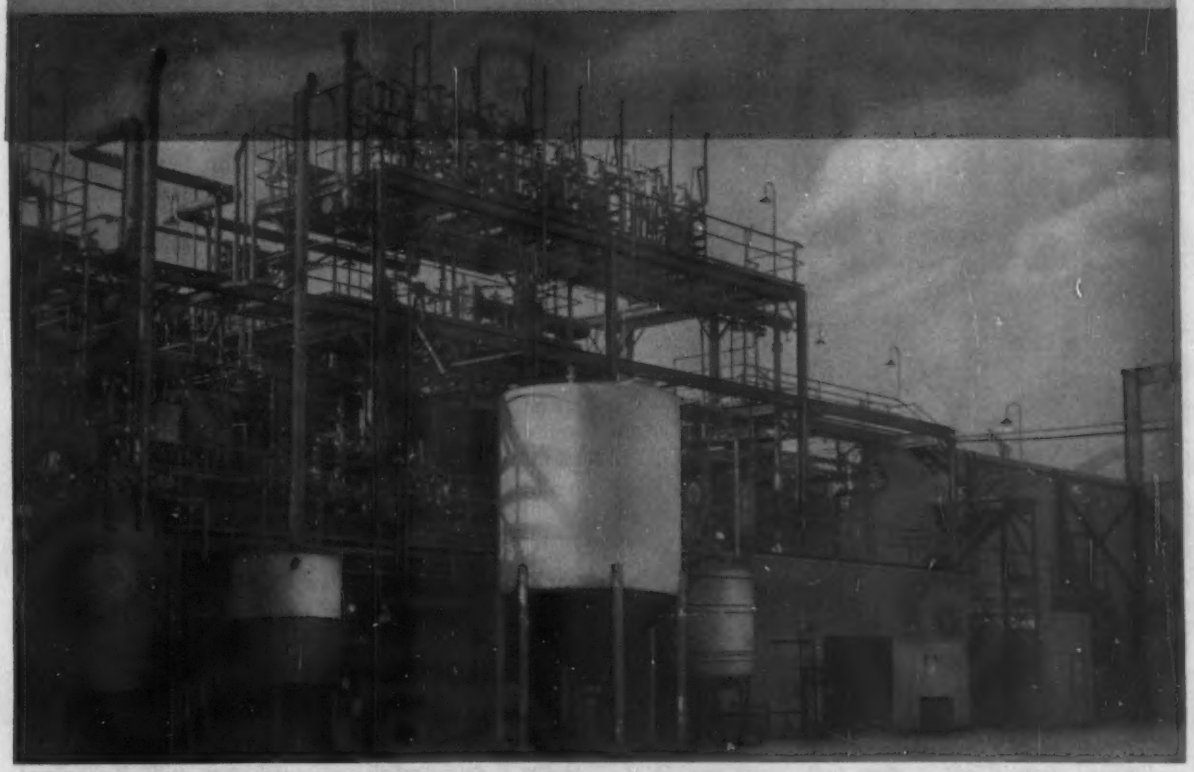
J&L — A GREAT NAME IN SUPPLIES

26

new chemical plant
DESIGNED AND BUILT IN JUST SIX MONTHS

Undivided responsibility for engineering, procurement and construction services enabled CATALYTIC to build a new, operating chemical plant in just six months!

This unique performance called for precise coordination between the client and the contractor—to CATALYTIC, this project was a welcome opportunity to meet the challenge of on-time, on-budget performance . . . to show SKILL, EXPERIENCE and IMAGINATION at work.



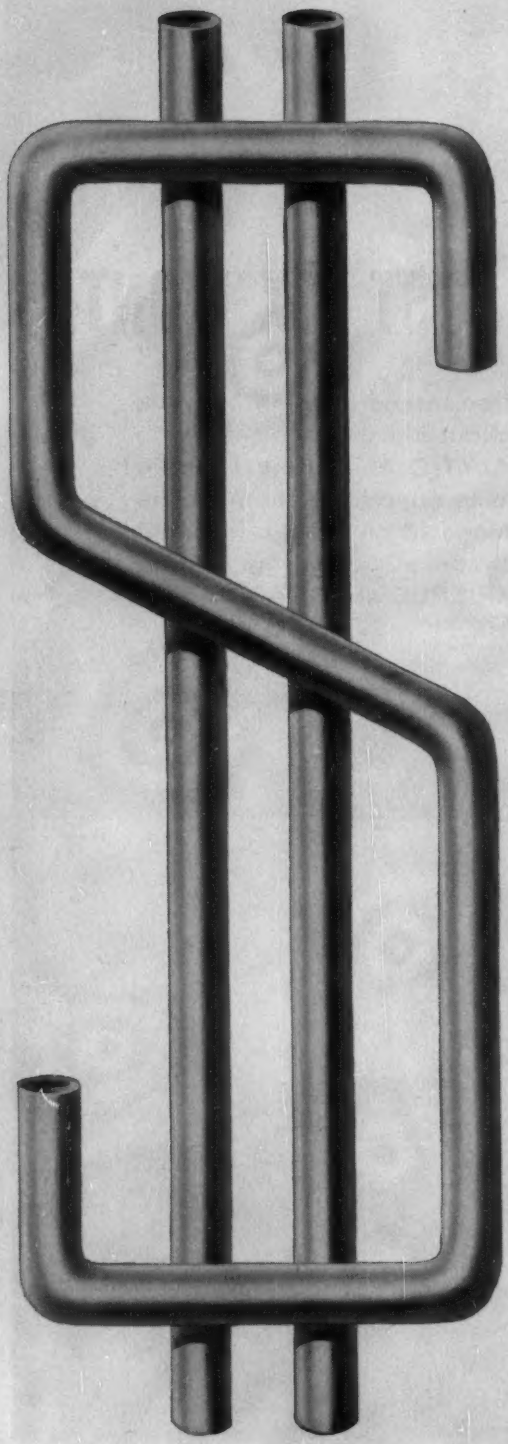
CATALYTIC
CONSTRUCTION COMPANY

Philadelphia 2, Pennsylvania
Baton Rouge, Louisiana
Toledo, Ohio • Tulsa, Oklahoma

In Canada: Catalytic Construction of Canada, Limited; Sarnia, Ontario; Toronto, Ontario; Montreal, Quebec

Catalytic *On-Time*...*On-Budget* Services for the metallurgical, chemical, petrochemical and oil refining industries: Project Analysis; Process Development; Process Design; Economic Studies; Engineering; Procurement; Construction.

For more data on advertised products, use Readers' Service Cards, last page.



Turn your pressure tube problems into savings

Timken Company metallurgists can select the one steel analysis that gives you maximum tube life-per-dollar

A lot of steels can solve the pressure, temperature and corrosion problem that your particular operation creates. But it takes skill to find the one and only steel analysis that gives you longest tube life for your dollar.

Timken Company metallurgists have the special skill to save you money while solving your pressure tube problem. They're recognized experts backed up by more than 25 years of research and experience in high temperature steels. They've solved hundreds of industry's toughest pressure problems the same way they'll solve yours—economically.

And they've got the steels at their fingertips. You can get Timken® seamless pressure tubes in sizes up to 11″ O.D. x 3¼″ wall—available in all stainless and alloy grades.

One analysis of Timken fine alloy steel will meet your operating conditions best. And you can be sure it's an accurate analysis because we make only electric furnace fine alloy steel and use rigid quality controls to give uniformity from heat to heat, order to order, tube to tube.

Get in touch with Timken Company metallurgists next time you have a pressure problem. They'll solve it the only way they know—economically. The Timken Roller Bearing Company, Steel and Tube Division, Canton 6, Ohio. Cable address: "TIMROSCO".

TIMKEN *Fine Alloy* **STEEL**

TRADE-MARK REG. U.S. PAT. OFF.

SPECIALISTS IN FINE ALLOY STEELS, GRAPHITIC TOOL STEELS AND SEAMLESS STEEL TUBING

11,028 independent businessmen like these serve you better with Standard's help

Wholesale distributor Bob Evans, Mesa, Arizona, uses a plant provided and maintained by Standard. We help Bob develop new business and back him with engineering assistance on his customers' lubrication problems.

Robert "Bob" A. Juner, San Francisco, operates his own service station. We supply him with business forms, maps, lube guides and major equipment. Bob makes good use of Standard's training programs to improve his service to you.

Standard's special Aviation Division helps airport dealers like Frank Kelsey, Salt Lake City, Utah, with wind direction indicators, flight guides and credit card service . . . all welcome conveniences to his customers.

Standard credit cards make it possible for independent marine dealers like Joe Faires, Port Angeles, Wash., to honor charge accounts. When fuel and lubrication problems arise, his customers can rely on help from Standard's engineers.

Liquefied Petroleum Gas dealers like Louis Marx, Atascadero, California, find our operations manual helpful in almost every phase of his business . . . especially when it comes to saving customers time and trouble on deliveries.

Keith L. Tweedie, Salem, Oregon, is a heating oil distributor. Our complete program shows him how to set up an accounting system, handle credit, cut operating expenses and give you the cleanest, most convenient service possible.

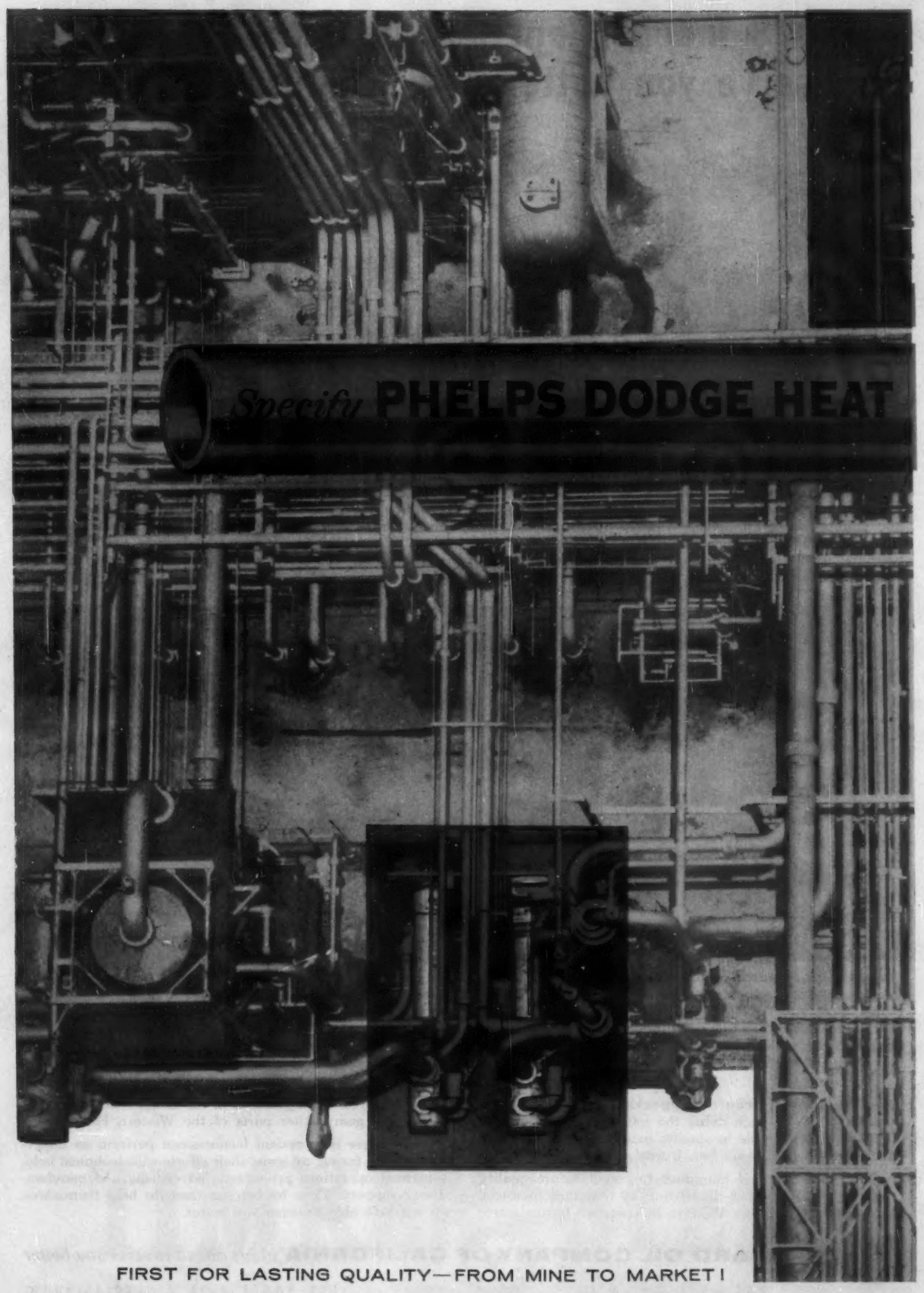
"Big Business" creates opportunities for "small business." With each doing the job for which it is best qualified, both are able to operate more efficiently . . . give you better service. Here's how it works with us.

Standard research and manufacturing skill assure quality products. In turn 11,028 distributors of Standard products, represented by these six Western independent businessmen, help bring you these products in the U. S., Alaska, Hawaii, B. C. and many other parts of the Western Hemisphere.

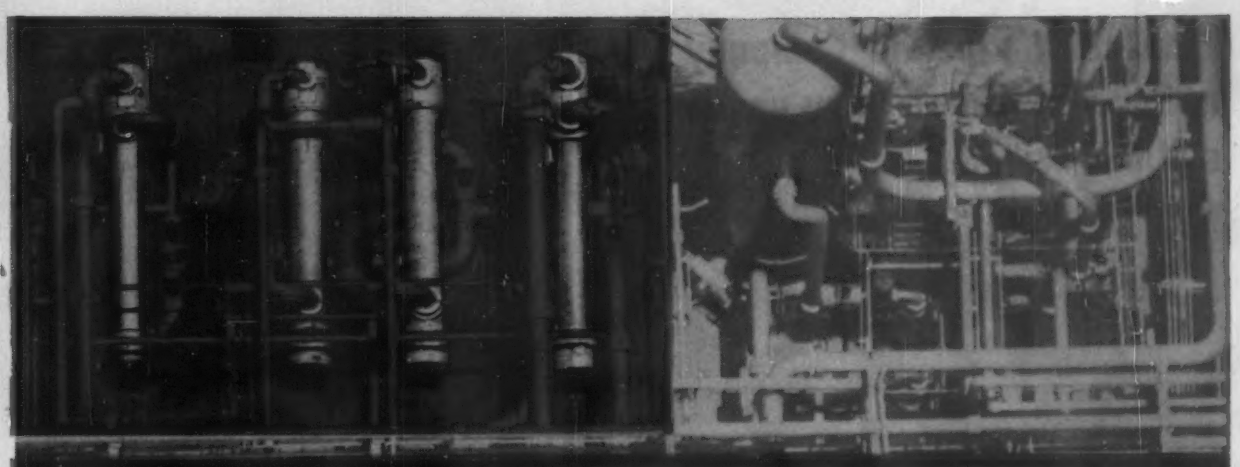
Because these independent businessmen perform an important service for us, we assist their efforts with technical help, suggested operations procedures, advertising and merchandising support. Thus by helping them to help themselves, we are *both* able to serve you better.

STANDARD OIL COMPANY OF CALIFORNIA *plans ahead to serve you better*

For more data on advertised products, use Readers' Service Cards, last page.

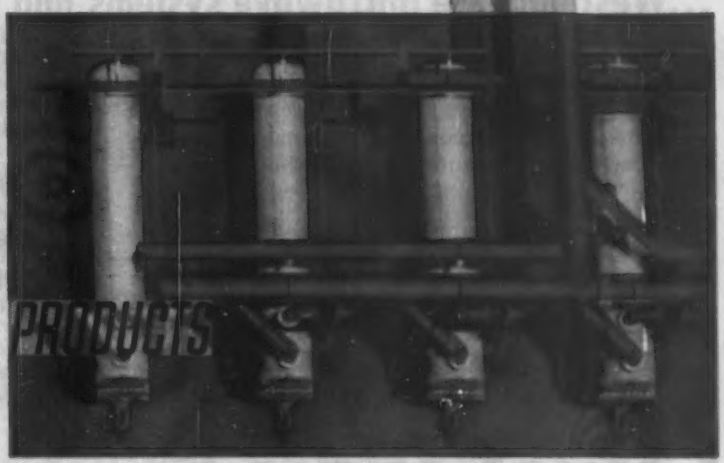


FIRST FOR LASTING QUALITY—FROM MINE TO MARKET!



EXCHANGER TUBES *for Longer Service!*

- Full range of copper-base alloys for every application.
- Vast background of application engineering to assist in proper alloy selection.
- Complete control of quality throughout every step of manufacture.

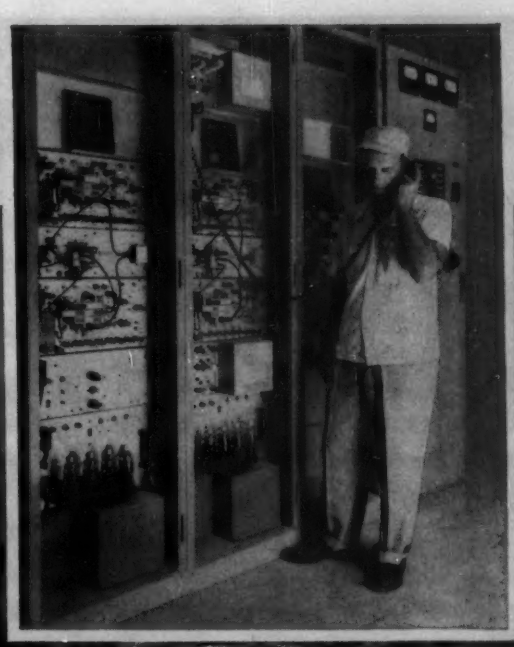


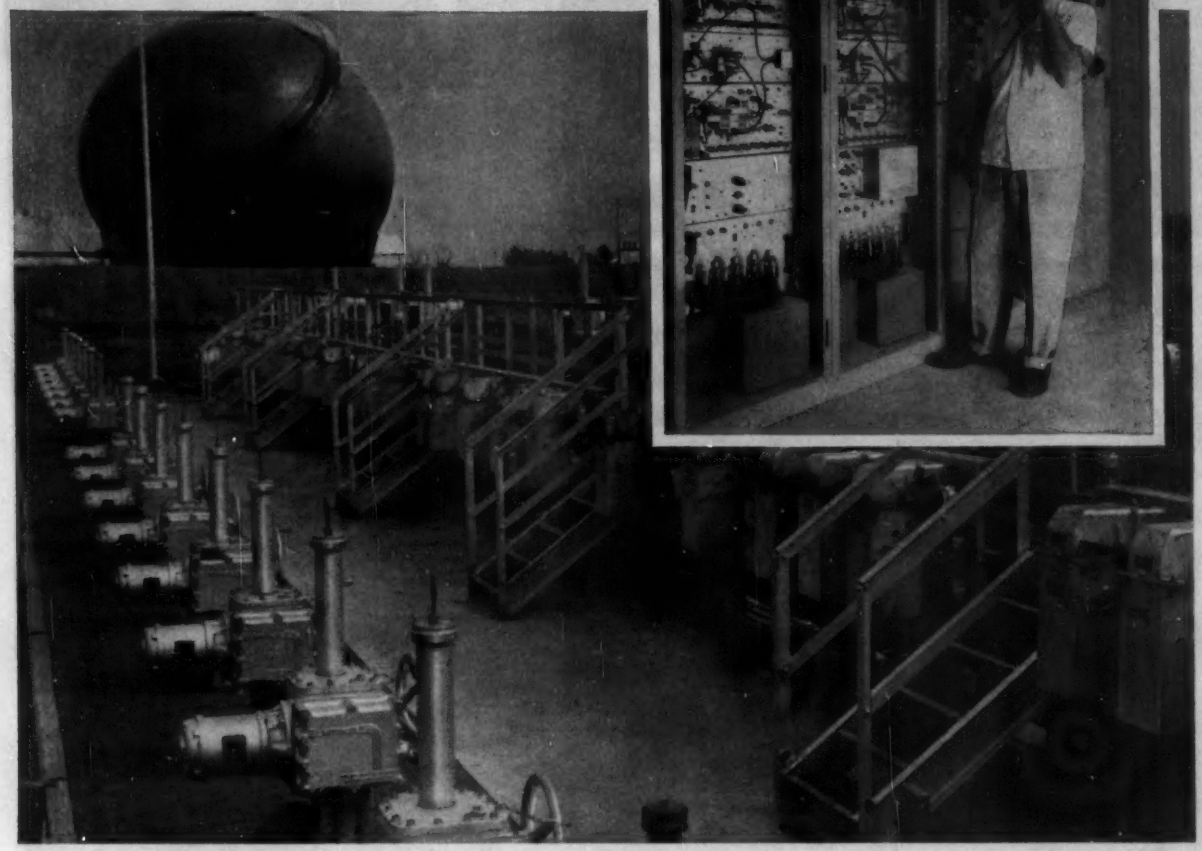
PHELPS DODGE COPPER PRODUCTS CORPORATION

SALES OFFICES: Atlanta, Birmingham, Ala., Cambridge, Mass., Charlotte, Chicago, Cincinnati, Cleveland, Dallas, Detroit, Fort Wayne, Greensboro, N. C., Houston, Jacksonville, Kansas City, Mo., Los Angeles, Memphis, Milwaukee, Minneapolis, New Orleans, New York, Philadelphia, Pittsburgh, Portland, Ore., Richmond, Rochester, N. Y., San Francisco, St. Louis, Seattle, Washington, D. C.

For more data on advertised products, use Readers' Service Cards, last page.

Plantation Pipeline Company has reliable control of many unattended stations with...





...Westinghouse Microwave systems and LimiTorque valve operators

With a Westinghouse Microwave Communications System and LimiTorque Remote Valve Operators, pipeline stations get not only positive control in "one complete package," but the most advanced telemetering and automatic push-button operation of valves . . . an ideal partnership for very efficient pipeline operation . . . proved by thousands of hours of actual operation. Voice panels adapt easily to any type of telephone service; telegraph units are quickly changed from one function to another.

LimiTorque Motorized Valve Operators are widely used on most all the major pipelines throughout the World; as well as in many well known refineries.

LimiTorque Operators open and close valves automatically at just the correct speed . . . and are equally effective in hot or sub-zero climates . . . safely and dependably . . . in out-of-the-way or hazardous locations . . . and LimiTorque Operation saves time and money in man hours usually expended.

Write for Catalog L-550, and you'll understand why more LimiTorque Valve Operators are used than all others combined.

LimiTorque®

PHILADELPHIA GEAR WORKS, INC.
ERIE AVE & G STREET, PHILADELPHIA 34, PENNA.
Offices in all Principal Cities

INDUSTRIAL GEARS & SPEED REDUCERS • LIMITORQUE VALVE CONTROLS • FLUID MIXERS • FLEXIBLE COUPLINGS
Limitorque Corporation • Philadelphia

never before!

COMPACT, LOW-WEIGHT CONNECTORS WITH HIGH CURRENT RUPTURING RATINGS*

The new industrial series "C" Pyle-Star-Line connectors combine unique insulation and construction characteristics which make possible extraordinarily high circuit breaking ratings for the size and weight of the shell.

"Sandwich Insulation"—a resilient silicone insulation disc which floats between two rigid discs absorbs shock and vibration and permits the contacts to align themselves. The silicone, under pressure, reacts like a fluid. It flows into all crevices about the contact pins and sockets — positively prevents moisture or dust from passing through the insulation or accumulating to cause failures from short circuits or grounds.

Contact Inserts

Tough Anodic Coating of shell provides a smooth, attractive finish which has a hardness equal to 40 on the Rockwell C scale.

Rugged, Compact, Low-Weight Shell machined from high tensile strength aluminum...combined with the unique insulation features...provide a safe reliable, easy-to-handle connector which is highly resistant to the most punishing extremes of temperature, pressure, shock, vibration, corrosive dusts and moisture. Advantages never before combined in a single, standardized connector!

* **Listed by Underwriters' Laboratories** in circuit breaking ratings of 30, 60, 100 and 200 ampere, 600 volt, A.C.

Write for 64-page catalog, No. 1252-I

SINCE 1897

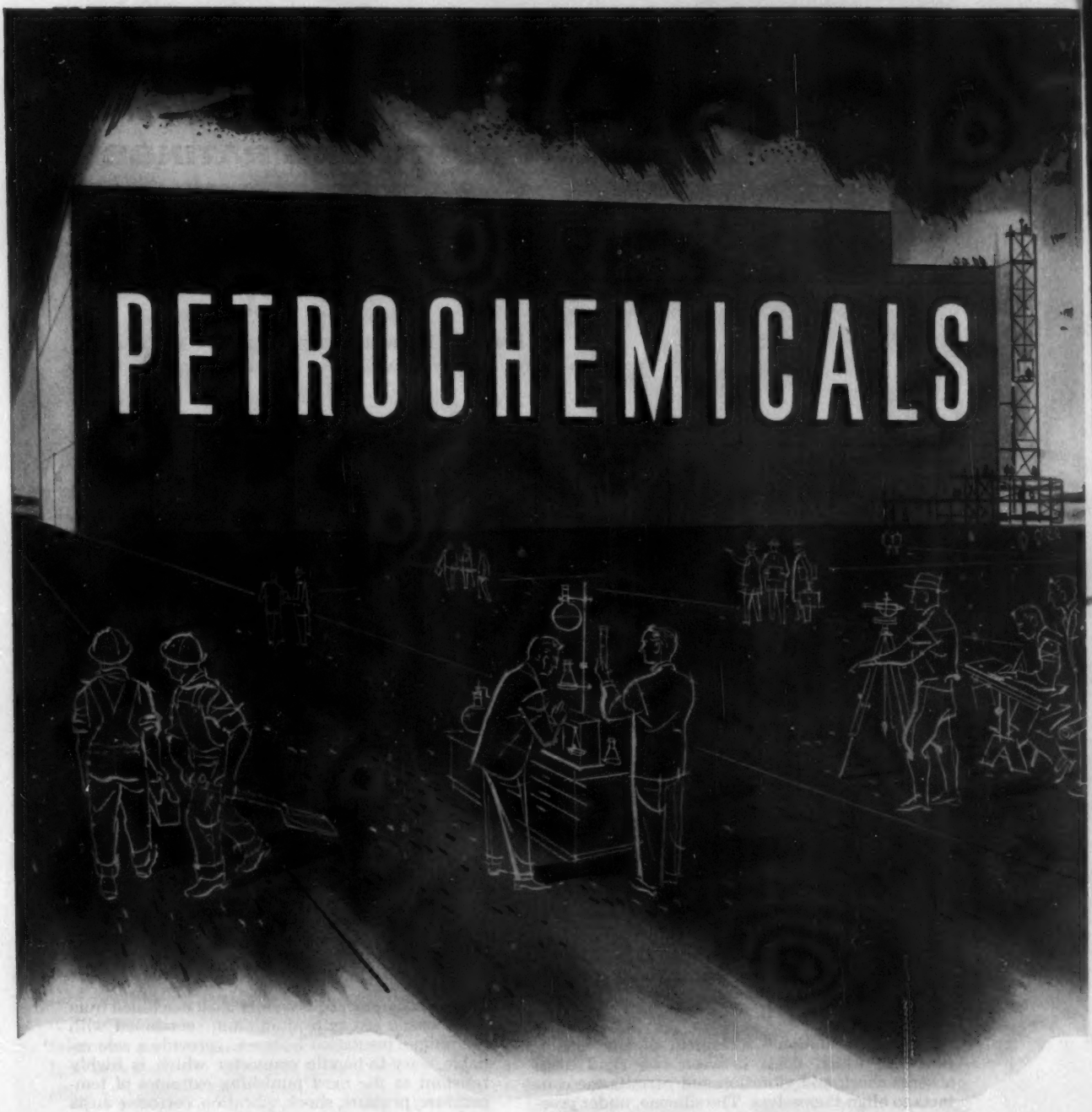
THE PYLE-NATIONAL COMPANY

WHERE QUALITY IS TRADITIONAL

1393 North Kostner Avenue, Chicago 51, Illinois

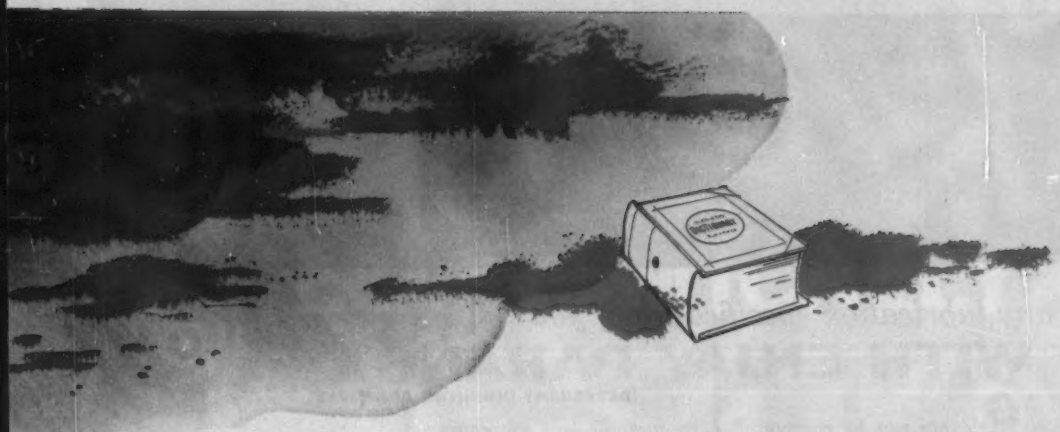
BRANCH OFFICES AND AGENTS IN PRINCIPAL CITIES OF THE U.S. AND CANADA • CANADIAN AGENT: THE HOLDEN CO., LTD., MONTREAL • RAILROAD EXPORT DEPARTMENT: INTERNATIONAL RAILWAY SUPPLY CO., 30 CHURCH ST., NEW YORK 7, N.Y. • INDUSTRIAL EXPORT DEPARTMENT: ROCKE INTERNATIONAL CORP., 13 E. 40TH ST., NEW YORK 16, N.Y.

CONDUIT FITTINGS • PLUGS AND RECEPTACLES • LIGHTING FIXTURES • FLOODLIGHTS



Research and engineering at UOP have been working for years developing and perfecting processes for producing petrochemicals. These are some of the UOP petrochemical processes now available to the refining industry . . . CATALYTIC CONDENSATION . . . OLEFIN EXTRACTION FOR BUTYLENE RECOVERY . . . CATALYTIC DEHYDROGENATION . . . HYDRAR® . . . UDEX® . . . TWO-STAGE UNIFINING* . . . AROSORB . . . ALKAR* . . . BUTAMER*

* Trademark



What it takes to build a new word

If your dictionary isn't the latest copy, chances are you won't find the word "Petrochemical" in it. It only got into the book a year or so ago. But a lot of time, thought and work went into its building. For many years scientists, designers and engineers in the petroleum industry have been developing the techniques for producing these important by-products that today make this word a most important one in our economy. For instance, here at UOP our research and engineering staff have been working for years, actively developing processes which yield valuable petrochemicals from petroleum raw materials and refinery by-products. Today UOP makes available to all refiners a number of petrochemical processes. These provide chemicals for the synthetics which have become part of our daily lives through their application to so many products now essential to our standard of living. Too, they help improve the economic efficiency of petroleum refining. UOP will be glad to supply, without obligation, individual recommendations for the practical application of its various petrochemical processes to any refining operation, anywhere in the free world.

UOP®

UNIVERSAL OIL PRODUCTS COMPANY

30 ALGONQUIN ROAD, DES PLAINES, ILLINOIS, U. S. A.

More Than Forty Years Of Leadership In Petroleum Refining Technology

you can meet any lubrication specification if you

BLEND WITH ENJAY PARANOX®

(DETERGENT-INHIBITOR ADDITIVES)

Blended with Paranox, lubricants can be compounded to combine *both* minimum wear and maximum engine cleanliness characteristics. That's why more and more refiners and blenders are relying *exclusively* on Paranox in formulating lubricants for heavy duty equipment and all engines that are subjected to tough operating conditions.

Through years of intensive research and development work with manufacturers and oil companies, Enjay has developed the only *complete line* of high quality additives (Paramins®) that can assure *maximum* performance characteristics. Why not let this experience and know-how work for *you*? Contact the Enjay Company today.

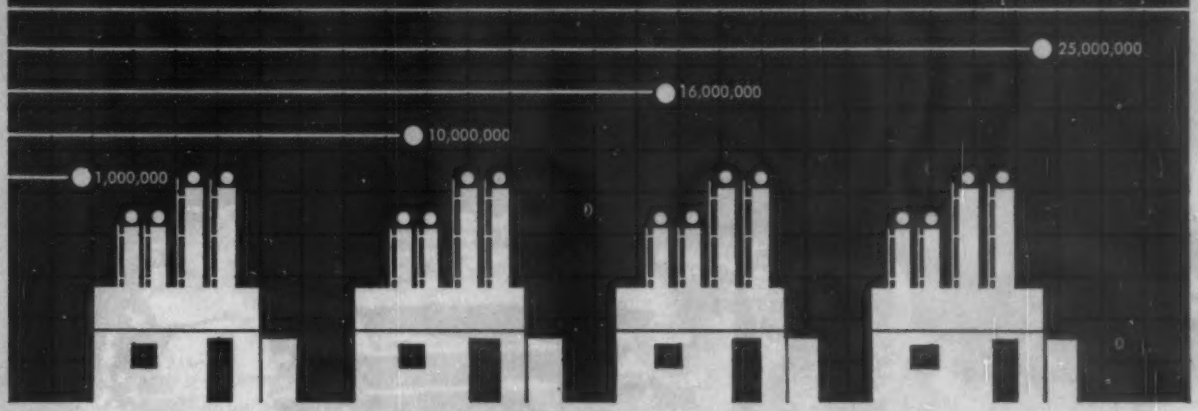
ENJAY

Pioneer in Petrochemicals

ENJAY COMPANY, INC., 15 WEST 51st ST., NEW YORK 19, N. Y.

Akron • Boston • Charlotte • Chicago • Detroit • Los Angeles • New Orleans • Tulsa

RUSSCO gas processing plants grow with your gas production... ECONOMICALLY



A gas processing plant can be constructed on your lease by Russell Engineering Corporation to profitably handle as little as one million cubic feet of rich gas per day. Then as your production increases other plants can be quickly added to process any increased quantity of gas. As production declines, the portable Russco plants can be moved to a new site at minimum cost.

Russco plants are now operating from New Castle, Wyoming, to Kingsville, Texas, with minimum attendance. These installations operate at top efficiency in temperatures ranging from 40° below zero to 105° in the shade. Why not find out for yourself how *Russco specialized processing equipment* can benefit your operation.

FOUR REASONS WHY RUSSCO IS YOUR BEST SMALL PLANT BUY

1. **Simple Design:** This efficient, low-cost refrigerated-absorption unit removes problem-water and liquid hydrocarbons, and produces fractionated liquid products.
2. **Russco Thermo-Syphon Reboiler:** A direct-fire reboiler *proven safe* in over one million hours of heater use. Standardized design makes this a low cost unit, completely eliminating hot oil circulating pumps.
3. **Russco Air Cooled System:** Water problems are completely eliminated with the Russco water-free system.

4. THE RUSSCO SERVICE POLICY:

At Russell Engineering Corporation *service* is always *first*. Russco engineers help survey your problems, then design and construct your plant to meet your individualized needs. Russco engineers help you to maintain maximum plant efficiency after completion.

REC

RUSSELL ENGINEERING CORPORATION

Home Office: 2609 Sunset Blvd., P. O. Box 6731, Houston 5, Texas
Fabricating Plant: Fort Morgan, Colorado

For more data on advertised products, use Readers' Service Cards, last page.

ANOTHER IN A SERIES
OF MOTOR FACTS
FROM ALL INDUSTRIES

Westinghouse motors double normal life for this application

. . . at Ohio-Apex Div., Food Machinery and Chemical Corp.

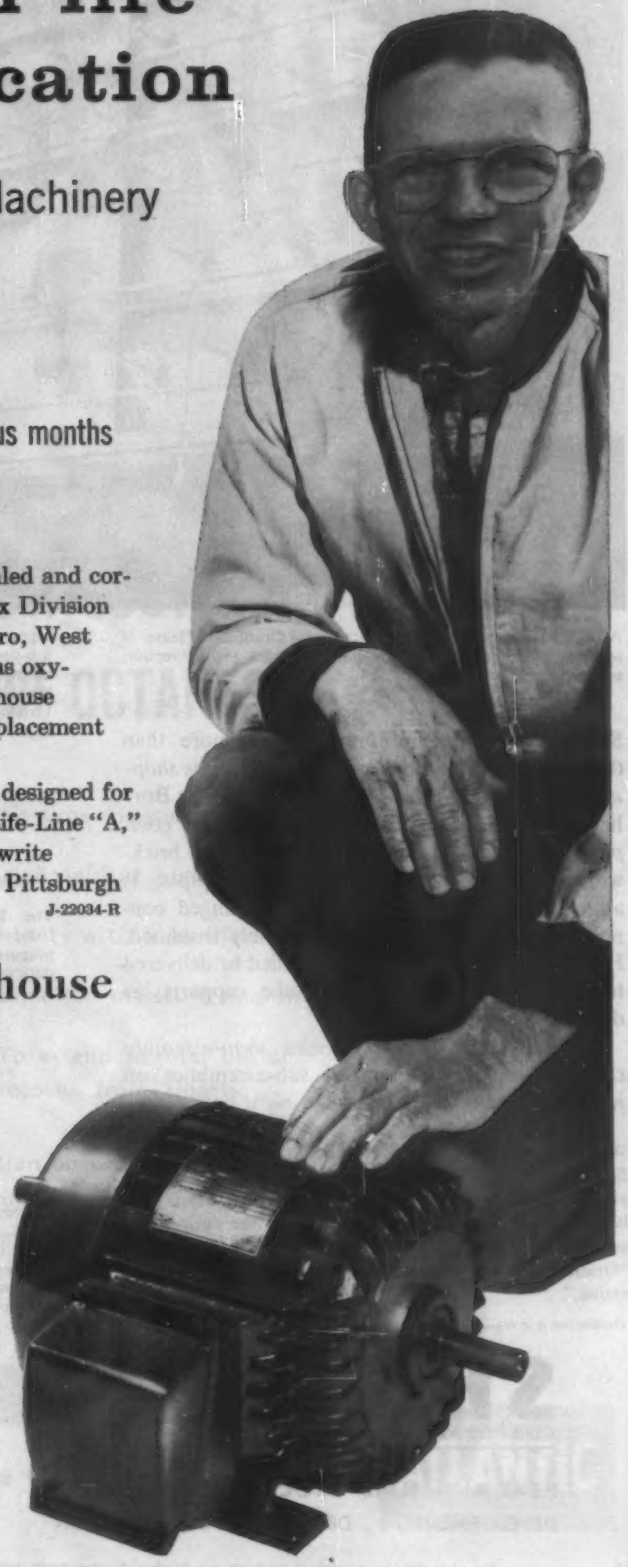
this standard Life-Line A motor
still pumping corrosive POC l_3 after 12 continuous months
without maintenance or down time

"We must have a dependable motor, completely sealed and corrosion-resistant," says Mr. Burton Fitch, Ohio-Apex Division of Food Machinery and Chemical Corporation, Nitro, West Virginia. "A corrosive atmosphere, plus phosphorous oxychloride drip and seepage, cuts motor life. Westinghouse Life-Line® "A" motors have already passed this replacement point twice . . . and are still going strong."

Westinghouse motors last longer because they're designed for modern industry's needs. For more facts about the Life-Line "A," call your local Westinghouse representative . . . or write Westinghouse Electric Corporation, P. O. Box 868, Pittsburgh 30, Pennsylvania.

J-22034-R

YOU CAN BE SURE... IF IT'S Westinghouse



←

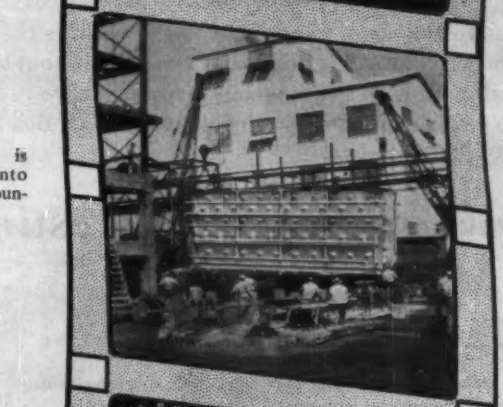
Unretouched photo of Life-Line "A" three-hp motor driving chemical pump at 1730 rpm, 100 gpm at Ohio-Apex.

"Westinghouse Life-Line "A" motors have cut our motor costs substantially . . . helped us keep our chemicals moving down the line," says Mr. Fitch of Ohio-Apex. "Their built-in ruggedness, plus foolproof sealing against corrosion, means longer life, lower maintenance."

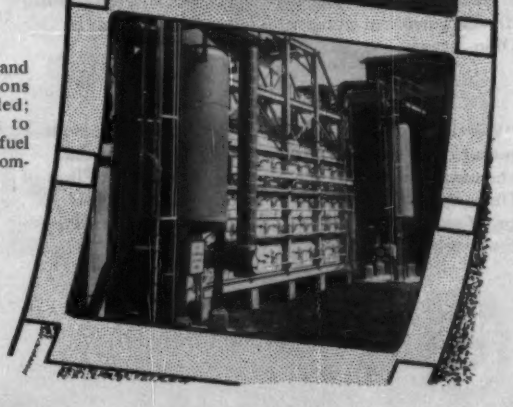
Selas prefabrication saves time and money at job-site

After final inspection, the completed Selas Gradiation Heater is securely anchored on flatcar for shipment. Stack and convection sections are in adjoining car.

Upon arrival at job-site, cranes allow flatcar to be slipped out, Lo Boy slipped in.



The heater is lowered onto prepared foundations.



Convection, and stack sections are installed; connection to process and fuel gas piping completes job.

SELAS prefabrication means much more than the accepted definition of prefabrication: it is *shop-assembly*. In capacities as large as 45 million Btu/hr coil duty, Selas Gradiation® Heaters are *complete* when they are shipped out: burners, brickwork, arch tiles are in place; manifold piping is attached and intact, complete with flanged connections; stacks and ducts completely insulated. Heating coils can be shipped installed or delivered to job-site, pre-assembled on tube supports, as desired.

In terms of field effort, Selas *shop-assembly* means complete erection of sub-assemblies on job-site foundations in less than eight hours!

Whatever your needs—*shop-assembly* or field-assembly—Selas Gradiation Heaters will give you longer "on-stream" periods, high conversions and selectivity, Zone Control of heat input, uniform heat distribution on the entire tube surface which extends tube life. Send for Bulletin 75 "Gradiation Heating for Petroleum and Chemical Processing."

Gradiation is a registered trade name of Selas Corporation of America.

SELAS
CORPORATION OF AMERICA

DRESHER, PENNSYLVANIA

HEAT AND FLUID PROCESSING ENGINEERS
DEVELOPMENT . . . DESIGN . . . CONSTRUCTION

CATFORMING

YOUR LOW-COST KEY TO HIGH OCTANES

CATALYSTS — Specific type for your problems.

SELECTIVITY — Superior yield at high octanes.

STABILITY — High activity with long life.

DURABILITY — Tolerance for moisture and nitrogen.

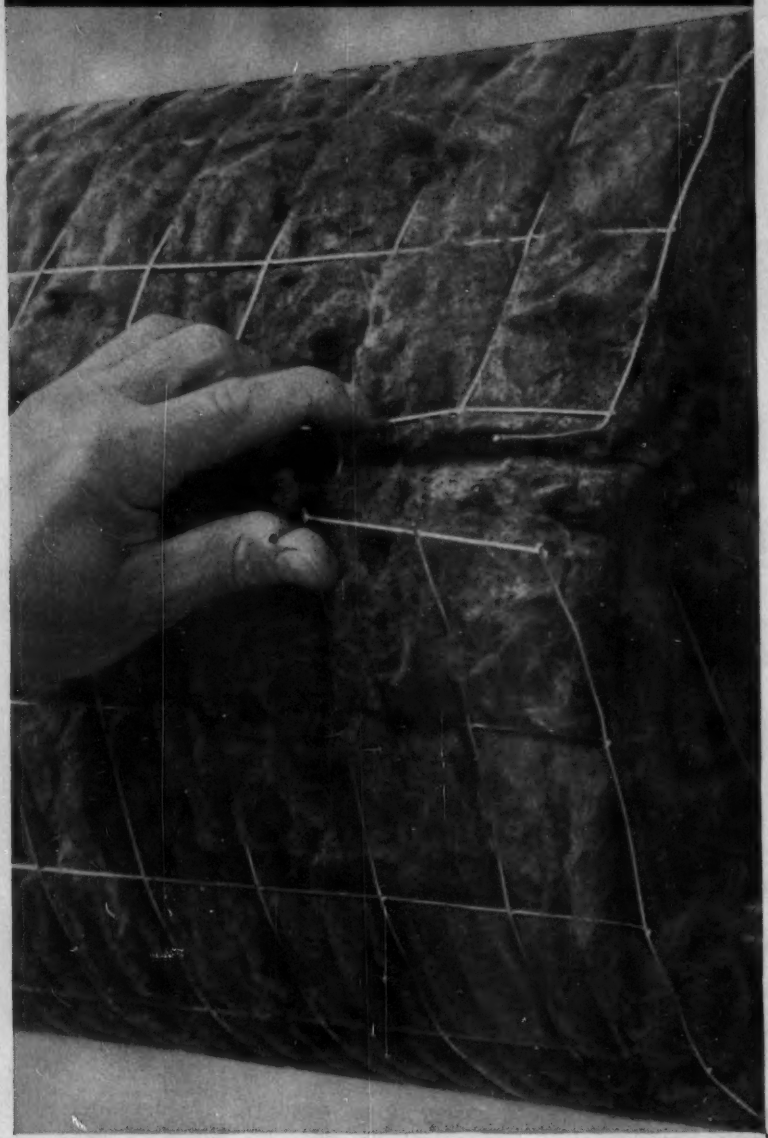
REGENERATION — To extend normal life or recover from upsets.

For further information on Catforming, write or wire The Atlantic Refining Company, P. O. Box 8138, Philadelphia 1, Pennsylvania.

it's the **CATALYST** that counts **ATLANTIC**

For more data on advertised products, use Readers' Service Cards, last page.

NOW—High Speed Fastening Lowers Applied Cost with . . .

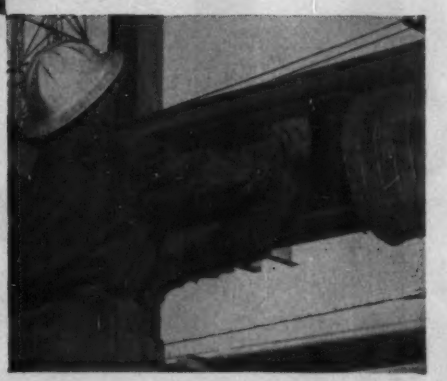


BALDWIN-HILL NEW NUMBER 101 PIPE INSULATION

By threading lead wires under the opposite stay wires and bending ends up and over into the felted blanket, each 2 ft. section of B-H No. 101 Pipe Insulation is secured around the pipe or pipes in a matter of minutes. This pays off in saving time and money, particularly on long runs of large diameters up to 30". No costly or time-wasting banding is necessary. Outside finishes of metal sheet or roofing felt are applied directly over the insulation.

B-H No. 101 is fabricated to a uniform density of high temperature and moisture resistant spun mineral wool, specially felted to interlock the fibers and prevent fallout. The insulation is effective on piping heated to 1200° F.

Write for new brochure on B-H No. 101 Pipe Insulation or refer to Baldwin-Hill catalog in Sweet's Plant Engineering File.



BALDWIN-HILL COMPANY

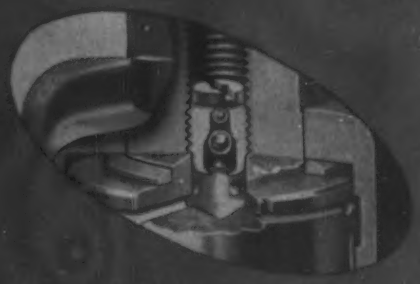
705 Breunig Avenue, Trenton 2, N. J.

Kalamazoo, Mich. . . . Huntington, Ind. . . . Temple, Tex.

For more data on advertised products, use Readers' Service Cards, last page.

In the spots that count... Homestead Valves are

LEAKPROOF



Reinforced Teflon and lubricant seal

Controlled pressurized lubricant seal

Lower cost per year valve service is guaranteed by Homestead Lubricated Plug Valves. These are the features that make them leakproof and extend their useful life . . . reinforced Teflon* head seal, double ball and lubricant sealed check valve, and their exclusive controlled pressurized lubricant seal.

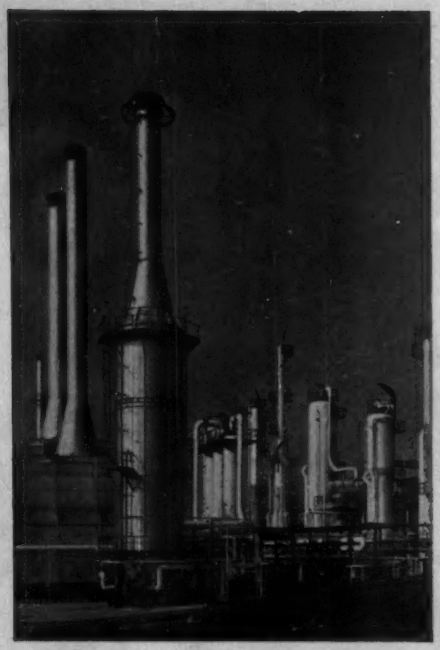
Homestead's controlled lubricating system forces a chemical film over all sealing surfaces at more than 300 pounds pressure. In addition, it prevents sticking, by its piston-like movement of the plug during each lubrication. See how Homestead fills your valve needs. Write today for Reference Book 39, (Section 5), for complete information on Homestead Lubricated Plug Valves.

*DuPont registered trademark.

h v

HOMESTEAD VALVE MANUFACTURING COMPANY

P. O. Box 45 • Coraopolis, Pa.



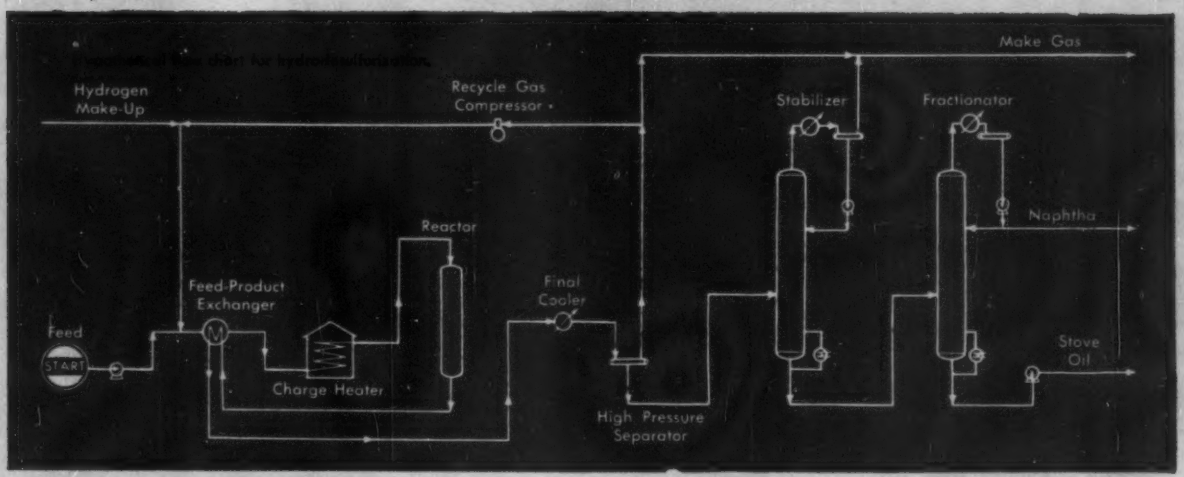
Unifining Unit, Union Oil Company of California refinery, Oleum, California uses Harshaw Cobalt Molybdate Catalyst.

For Hydrodesulfurization

HARSHAW COBALT MOLYBDATE CATALYST

★ **223 regeneration cycles without loss in activity**—a typical performance given by Harshaw Cobalt Molybdate Catalyst, accomplished while treating one of the most difficult charge stocks.

★ **Recording less than 1.0¢/bbl. accumulated costs**—with no indicated loss of activity, Harshaw CO-MO has been full scale tested the longest of any hydrodesulfurization catalyst.



Since you know the critical ingredient of any catalytic hydrogenation reaction is the *catalyst*, the above facts should prompt you to acquire complete details on this premium commodity in the field of catalytic hydrogenation. We shall be happy to point out the many specific advantages that come with using Harshaw Cobalt Molybdate Catalyst and discuss any specific application you may be considering.

Feel free to contact your nearest Harshaw office

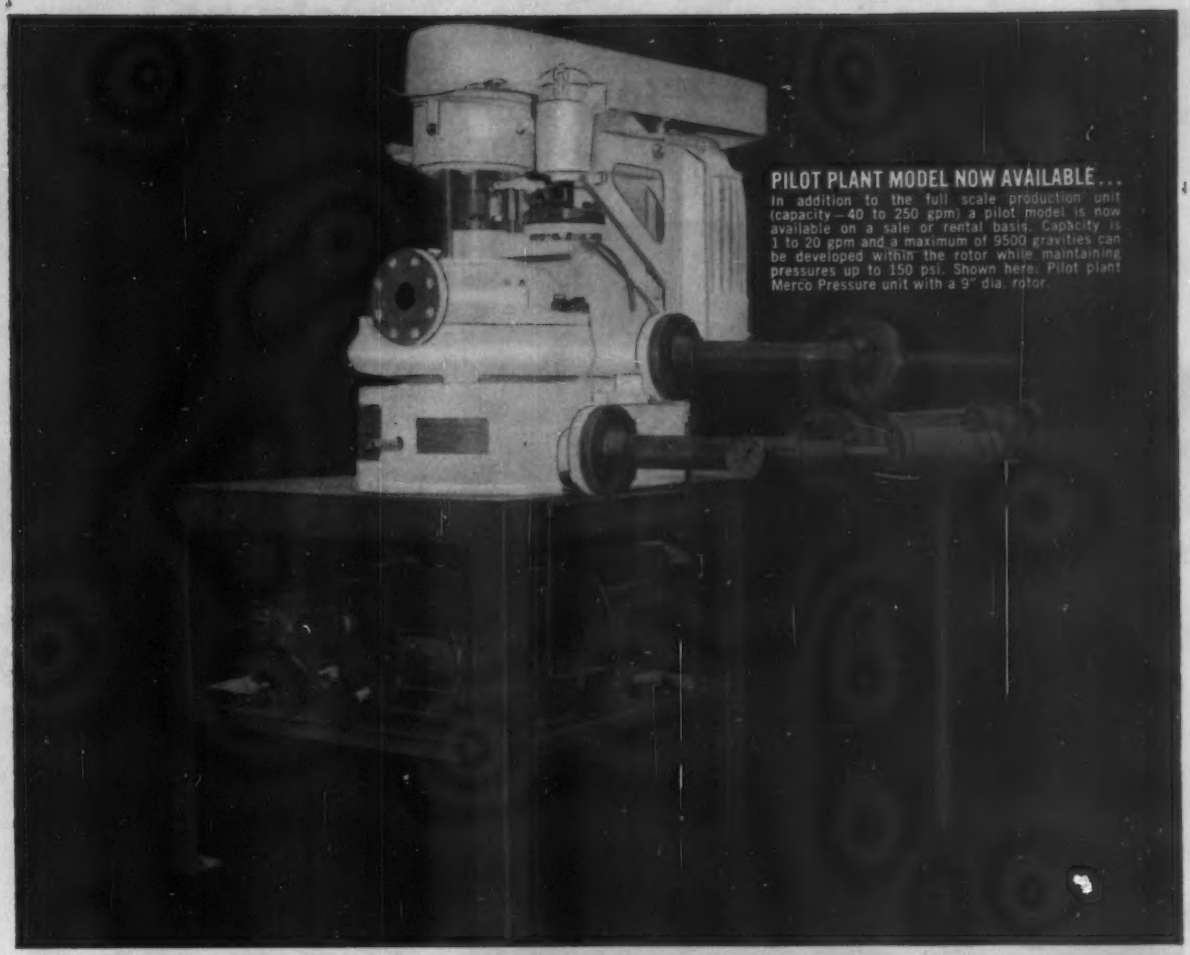
HARSHAW

THE HARSHAW CHEMICAL CO.

1945 E. 97th Street · Cleveland 6, Ohio

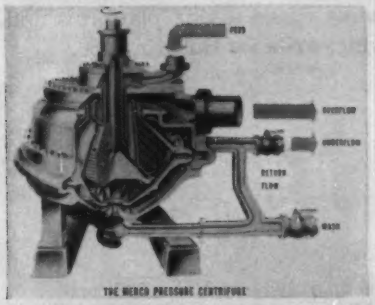
Chicago
Cincinnati
Cleveland
Detroit
Hastings-On-Hudson, New York
Houston
Los Angeles
Philadelphia
Pittsburgh

For more data on advertised products, use Readers' Service Cards, last page.



PILOT PLANT MODEL NOW AVAILABLE...
In addition to the full scale production unit (capacity – 40 to 250 gpm) a pilot model is now available on a sale or rental basis. Capacity is 1 to 20 gpm and a maximum of 9500 gravities can be developed within the rotor while maintaining pressures up to 150 psi. Shown here: Pilot plant Merco Pressure unit with a 9" dia. rotor.

INTERESTED IN PRESSURE CENTRIFUGING?



Illustrative drawing of a full scale Merco Pressure Centrifuge with a 30" dia. rotor bowl.

Latest addition to the Merco line of centrifugal equipment is the new Pressure Centrifuge. Originally developed for a catalyst removal step in the production of linear polyethylene, this new unit shows definite promise in a variety of refining and petrochemical applications.

Incorporating the unique return flow principle, this Merco can concentrate, wash, clarify, classify and recover soluble values . . . all at pressures up to 150 psi. There is no nozzle clogging nor solids build-up within the unit. The overhead drive eliminates the need for a submerged bearing; and a built-in, hydraulic hoist simplifies inspection and maintenance.

If there's a step in your flowsheet where centrifuging fits in and where pressure or vapor tight conditions must be maintained, you'll want new Bulletin No. 2600. Write for a copy to Dorr-Oliver Incorporated, Stamford, Connecticut.

DORR-OLIVER
INCORPORATED
WORLD-WIDE RESEARCH • ENGINEERING • EQUIPMENT
STAMFORD • CONNECTICUT • U. S. A.

For more data on advertised products, use Readers' Service Cards, last page.

Where a misstep costs $500... Blaw-Knox Electroforged® Steel Grating provides safer non-slip footing

Stair falls cost industry over $60,000,000 a year.

An average accident amounts to a loss of $500 in claims.*

A good way to guard against these profit-eating accidents is to construct your stair treads, walkways and floors with Blaw-Knox Electroforged Steel Grating. Non-slip twisted crossbars and a wide variety of bearing bars are available to meet every kind of working condition—safely solving the most hazardous skid situations.

Rigid, one-piece construction makes installation easy. Once on the job, Blaw-Knox grating practically takes care of itself. There is nothing to wear, nothing to patch, no dirt collecting corners to clean. It goes anywhere, fitting neatly around pipes, beams and machinery, admitting plenty of light and air to the area.

Made to your specifications, Blaw-Knox grating provides new highs in safety, easy up-keep and flexible application. For new ideas about grating—including space saving platforms and shelving, write for Bulletin 2486.

*Based on a study analyzing 803 compensable work injury claims closed in Illinois involving stairs and steps.

BLAW-KNOX

BLAW-KNOX COMPANY

Equipment Division
Dept. D, Pittsburgh 38, Pennsylvania

Complete Cost-Conscious Construction

the men, the method, the means . . .

Tellepsen engineers are qualified by years of experience to design the plants and processes required for every specialized phase of the petroleum and chemical industries. Use of scale models is an integral part of Tellepsen's cost-conscious planning procedure.

ECONOMIC RESEARCH & REPORTS
APPRAISALS • FIELD SURVEYS
PROCESSING • MODELS DESIGN

Tellepsen maintains a large staff of experienced mechanical, electrical and structural designers and draftsmen to translate the ideas of the planning group into working drawings.

DESIGN AND ENGINEERING

Major field installations are constructed by Tellepsen for the petroleum and chemical industries throughout the United States and in foreign countries.

FABRICATION
PROCUREMENT & EXPEDITING
CONSTRUCTION SUPERVISION
INITIAL PLANT START-UP

TELLEPSEN PETRO-CHEM CONSTRUCTORS

A Division of Tellepsen Construction Company

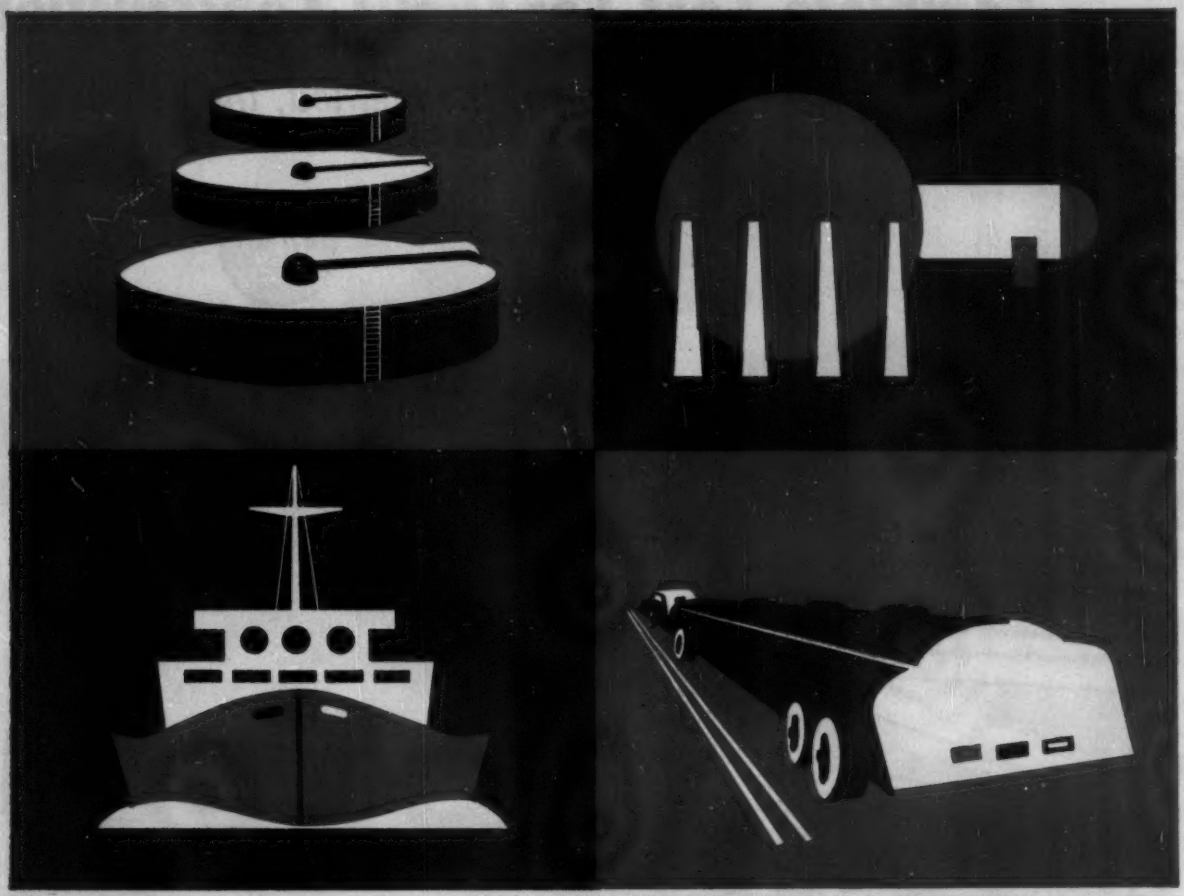
P. O. BOX 2536 • HOUSTON, TEXAS • TELETYPE HO-101

CABLE — "Tellecon"

MEXICO: Tellepsen de Mexico, S.A. de C.V. — Mexico, D.F. VENEZUELA: Trans-Caribbean, S.A. — Maracaibo, Ven.

LICENSED PROCESSORS FOR REFINERIES • LICENSORS FOR TELLEPSEN-DEVELOPED PROCESSES • ENGINEERS AND CONSTRUCTORS FOR THE PETROLEUM, CHEMICAL AND PETRO-CHEMICAL INDUSTRIES ANYWHERE IN THE WORLD.

Your enquiry will receive prompt, confidential attention—without obligation, of course.



World's most complete line of Storage Tank Fittings

Only Shand and Jurs offers world-wide availability and service on mechanical fittings — vents, gages and valves — for storage tanks. Stocks are maintained in key cities for prompt delivery to your tank farm, yard or depot.

Proved by over 36 years service, S&J tank fittings have set the industry standard for economy, safety, accuracy and dependability. Call or write your nearest S&J office for catalog and prices on the type of fittings you need.

S&J is also a world-leader in the manufacture of electrical remote supervisory control equipment.

SHAND AND JURS

GENERAL PRECISION EQUIPMENT CORPORATION GPE

2600 Eighth Street, Berkeley, California
Branch offices and representatives in principal cities

You save in many ways with TEL-O-SET receivers...

today's most advanced miniature pneumatic instruments

Record or indicate any process variables with versatile *Tel-O-Set* receivers. They're the most dependable, economical, and easily-serviced miniature instruments you can buy.

CUT INSTALLATION COSTS

- Startup is safeguarded by wiring and piping case separately . . . keep chassis safe in original carton until startup.
- Quick-connect design makes chassis mounting easy, fast, foolproof.

CUT SPARE PARTS INVENTORY

- Use any *Tel-O-Set* receiver with any pneumatic force-balance controller.
- Change recorder to indicator and vice versa . . . without changing case or disturbing field connections.

REDUCE PROCESS DOWNTIME

- All working parts can be inspected during operation, without process interruption.
- Zero and span, the only adjustments required, are set from front of panel.

SAVE IN MAINTENANCE

- Separate pneumatic and electric connections—no need for electrician to stand by.
- Linearity built in at factory, requires no attention.

Get complete details on receivers and other *Tel-O-Set* instruments from your nearby Honeywell field engineer. Call him today . . . he's as near as your phone.

MINNEAPOLIS-HONEYWELL, Wayne and Windrim Aves., Phila. 44, Pa.

Honeywell

First in Controls

When is a bargain not a bargain?

If your supplier neglects any one of nine important steps in the production of stainless steel plate his product may not be a bargain for you.

The wise buyer of stainless steel plate and plate products insists upon the solid service and sound methods of production that are identified with G. O. Carlson, Inc.

- Composition of each melt rigidly controlled to come well within the specification; with carbon always reported to the third decimal.
- Adequate trimming of both the hot top and butt end after the slab is rolled to guarantee sound material.
- Removal of all surface imperfections before the slab is rolled into plate.
- Annealing and rapid cooling of every chromium-nickel plate to produce material with the greatest corrosion resistance.
- Careful in-plant handling to minimize blemishes and imperfections.
- Close inspection of finished plates and the removal of minute flaws.
- Shearing, sawing, abrasive and flame cutting held to close tolerances to minimize costly machining and fitting in your plant.
- Rigid inspection of work throughout entire production cycle.
- Prompt, on-time delivery to maintain your production schedules.

G.O.CARLSON Inc.

Stainless Steels Exclusively

136 Marshalton Road
Thorndale, Pennsylvania
District Sales Offices in Principal Cities

PLATES • PLATE PRODUCTS • HEADS • RINGS • CIRCLES • FLANGES • FORGINGS • BARS and SHEETS (No. 1 Finish)

50 years

of making better instruments

May 1, 1958 marks the 50th anniversary of The Foxboro Company. Fifty years of leadership in process instrumentation. Fifty years of "either making a better instrument . . . or not making it at all."

On the next several pages are brief descriptions of current "Foxboro Firsts" that exemplify this basic company principle. Instruments that have contributed substantially to improved measurement and control throughout the process industries. Instruments that demonstrate what Foxboro leadership really means.

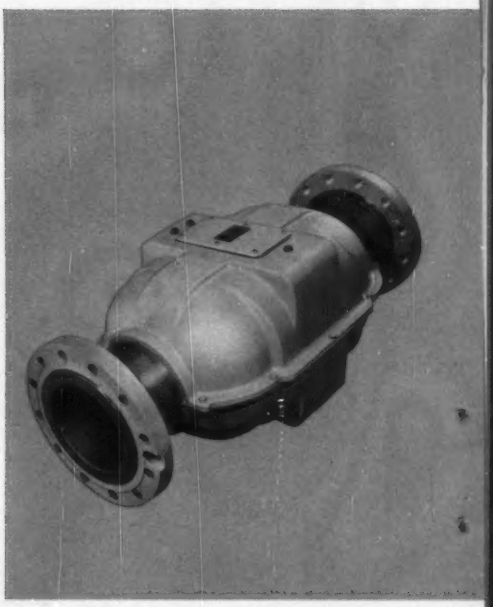
FOXBORO

REG. U.S. PAT. OFF.

CREATIVE DESIGN AND MANUFACTURE OF INSTRUMENTS
AND INSTRUMENT SYSTEMS FOR MEASURMENT AND CONTROL OF PROCESS VARIABLES.

Foxboro makes a better instrument

—or Foxboro doesn't make it!



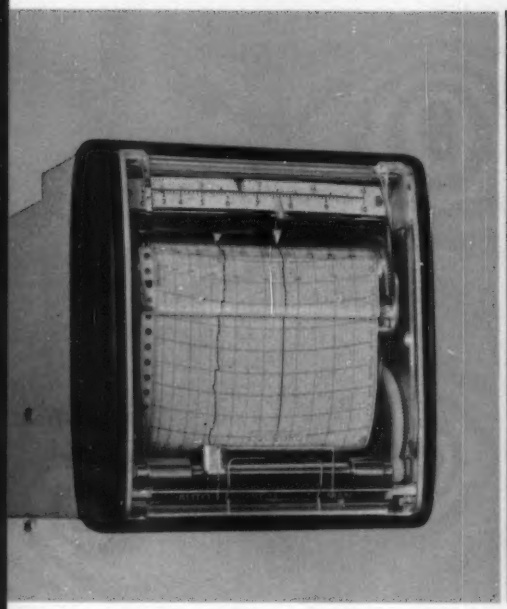
flow meter with
NO flow restrictions

FOXBORO MAGNETIC
FLOW METER

The Foxboro Magnetic Flow Meter, first introduced in 1954, represents a completely new approach to liquid flow measurement . . . an approach that triumphs over such metering headaches as turbulence, loss of head, density variations, viscosity, temperature changes, and plugged measurement connections.

A magnetic field is maintained across the meter tube. Liquid flowing through this field creates a voltage proportional to velocity. Flush electrodes pick up and transmit this voltage to a Foxboro Dynalog Recorder.

Magnetic Flow Meters are available in pipe sizes from 1/10 inch to over 6 feet. Ideal for measuring flows of chemicals, pulp stocks, slurries, and many other viscous and corrosive liquids. Equally effective for clear liquids.
Write for detailed Bulletin 20-14B.



"full-scale" small-case instrument for centralized control

CONSOTROL* RECORDING CONTROL STATION

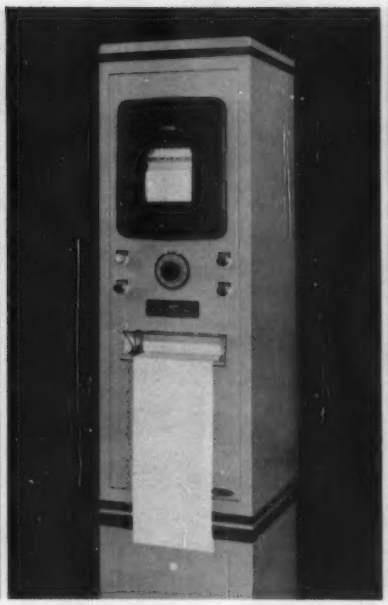
A small-case control station — compact yet with full-scale readability — is one of Foxboro's notable contributions to the centralized control field. The Consotrol Control Station, shown above, has a full-scale, 4-inch chart — the same length scale used on 12-inch circular chart instruments. Yet, four of these Consotrol Instruments can be panel-mounted where one conventional instrument used to go.

This Recording Control Station is a combination of the Consotrol Recorder and the Model 58 Controller, which mounts on the back of the recorder, or near the process.

With its unique "floating disc" design, and no slack diaphragms, the Model 58 quickly earned its reputation as the outstanding controller for the process industries.

Write for Bulletins 13-18A and 13-19.

*Reg. U.S. Pat. Off.

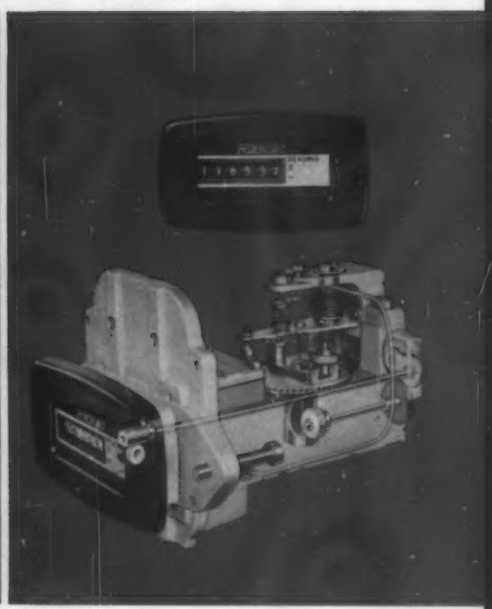


Radioisotopes harnessed for more sensitive measurement and control

FOXBORO SHEET WEIGHT PROFILER

This unique Foxboro development measures and records minute variations in the weight of paper and other web or sheeted materials. Measurement is made automatically by feeding a sample between a radioactive source and an ionization chamber detector. The amount of radiation passing through the sheet into the detector provides a deviation record of the weight of the sheet. This important quality-control measurement is far more rapid and accurate than was possible by any previous method.

The Sheet Weight Profiler is a typical example of how Foxboro engineers turn scientific advancements into better instruments for industry. **For full details, send for Bulletin PD 105-3.**



continuous, pneumatic flow totalizing

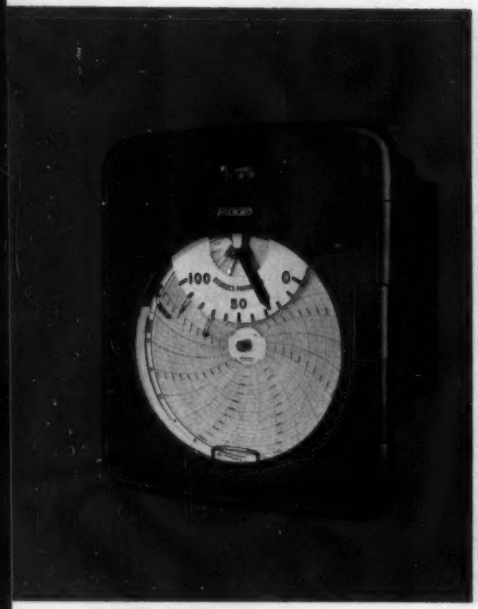
FOXBORO FLYBALL INTEGRATOR

An instrument that counts fluid flow — continuously! That's the achievement of Foxboro's unique "Flyball Integrator."

This totalizer completely eliminates conventional machined cams. Instead, a 3-15 psi air signal from a differential-pressure type flow transmitter is continuously balanced against the centrifugal force of a pneumatically driven turbine. Result — direct reading of actual flow units on the instrument counter. No converters — no intermittent increments.

Because it provides precise linear, continuous integration, the Flyball Integrator is ideal for the accounting of all process fluids and plant services.

For complete details, write for Bulletin 13-23.



"the potentiometer that has NO slidewire"

DYNALOG*
ELECTRONIC RECORDERS
AND CONTROLLERS

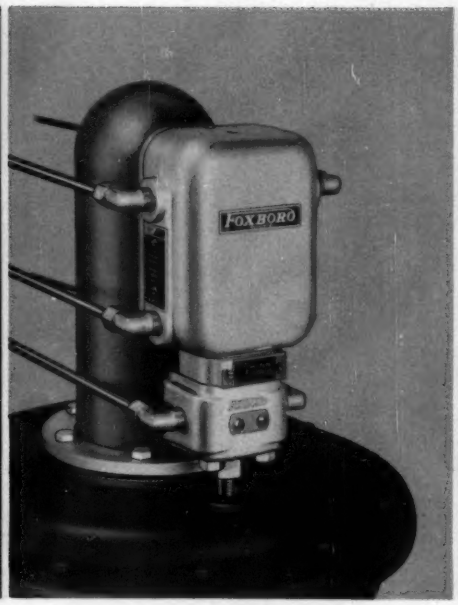
Measurement of process variables advanced radically with the development of Dynalog instruments.

These electronic instruments give stepless, continuous balancing, using a friction-free air capacitor instead of the conventional slidewire. There are no high-speed moving parts, no dry cells to replace, no interruptions even for automatic standardizing . . . and no lubrication. Dynalogs combine highest accuracy, sensitivity, and speed of response with unequaled freedom from maintenance.

Resistance, EMF, and capacitance type Dynalog Instruments are available for measuring and controlling temperature, pressure, flow, pH, conductivity, capacity, and many other process variables.

Write for Bulletin 20-10.

*Reg. U.S. Pat. Off.



new dynamic response in flow control . . .

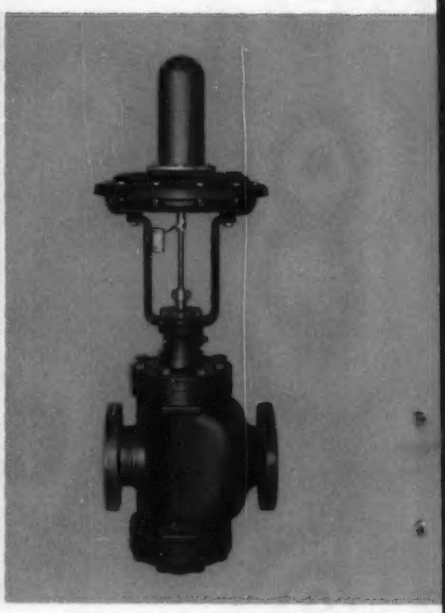
FOXBORO VALVE-MOUNTED
CONTROLLER

Controller-to-valve transmission lag is completely eliminated by this instrument, assuring unsurpassed speed of response — control that's precise, dynamic, smooth.

The M/59 is the *only* pneumatic receiver-controller specifically designed for direct mounting on the control valve motor. This unique force-balance controller has only two moving parts. There's nothing to align, nothing to wear out. A flexure-strip fulcrum eliminates friction and wear of conventional pivots . . . eliminates "conventional" maintenance.

Used with a flow transmitter, the M/59 gives live-action close-coupled response even when the operating panel is as much as 1,000 feet away.

For full information, write for detailed Bulletin 470.



control valve performance matched to control instruments

FOXBORO STABILFLO
CONTROL VALVES

Originally the control valve was considered the weak link in any pneumatic control system. Then Foxboro designed the air-operated Stabilflo control valve, the first valve with wide range, equal percentage V-port design.

These valves give precise, repeatable response for every change in control signal. They have equal percentage flow characteristics with a rangeability of 50 to 1 . . . so essential for maximum performance from proportional controllers.

One of the most copied designs in the industry today, Foxboro Stabilflo Valves are a processor's unqualified assurance of perfectly integrated pneumatic control systems.

For full details, write for Bulletin 5C-10.

Foxboro makes a better instrument

—or Foxboro doesn't make it!

differential pressure transmitter unequaled in accuracy, stability, and performance

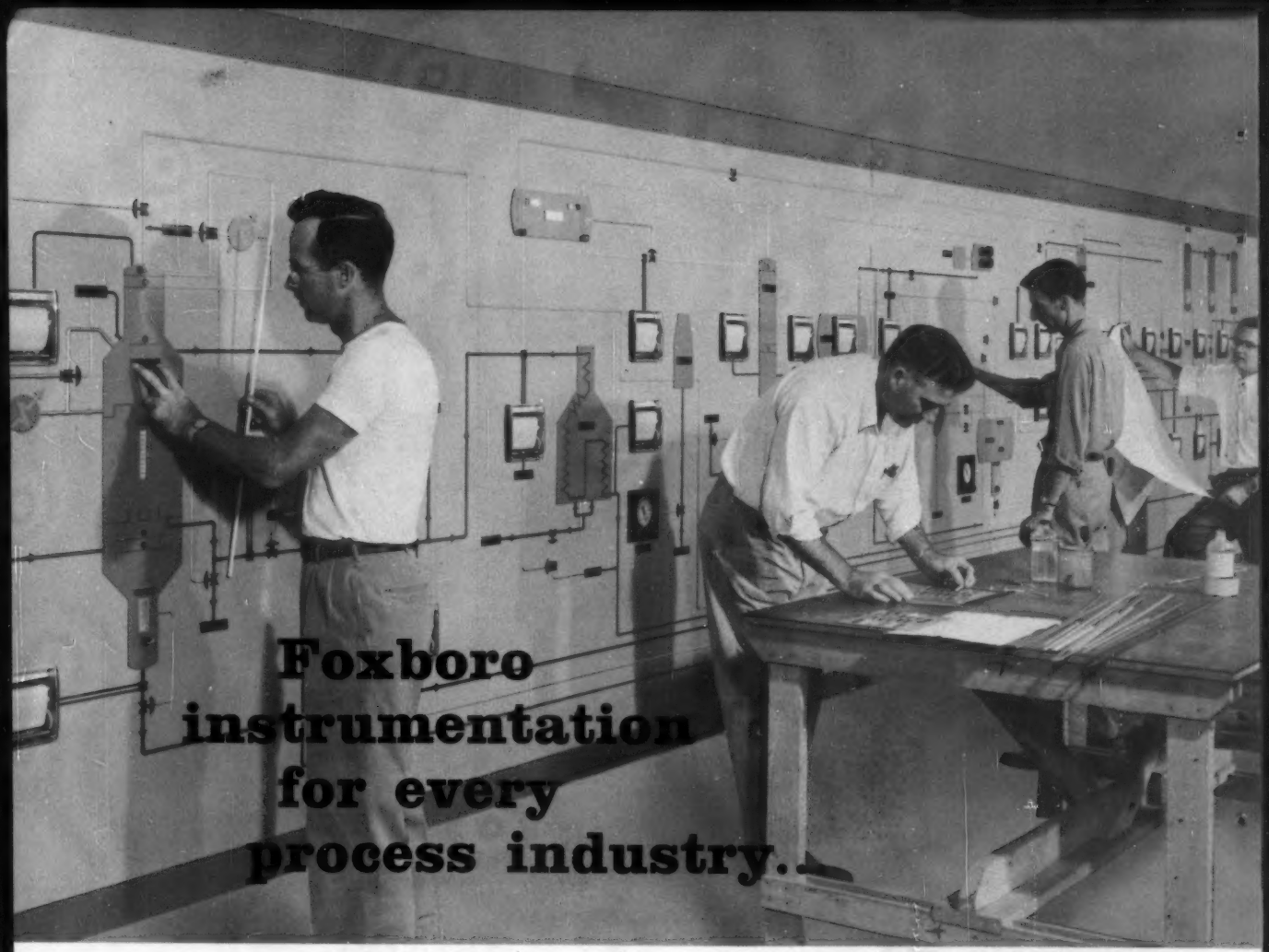
FOXBORO
d/p CELL* TRANSMITTER

Now and then, a manufacturer develops a product so superior in every respect that it becomes the "standard" for its industry. Such a product is the Foxboro d/p Cell Transmitter.

Pioneered 10 years ago, these differential pressure transmitters have established new standards of performance in flow measurement and control. Today, over 75,000 are in use—more than the total of all other makes put together.

d/p Cell Transmitters are now also available for liquid level control; measurement and control of extremely small flows; comparison of process and sample fluids; strain gauge systems; electronic inductive systems; for processes involving high static pressures, or elevated ranges. **Write for Bulletin 13-11A.**

*Reg. U.S. Pat. Off.



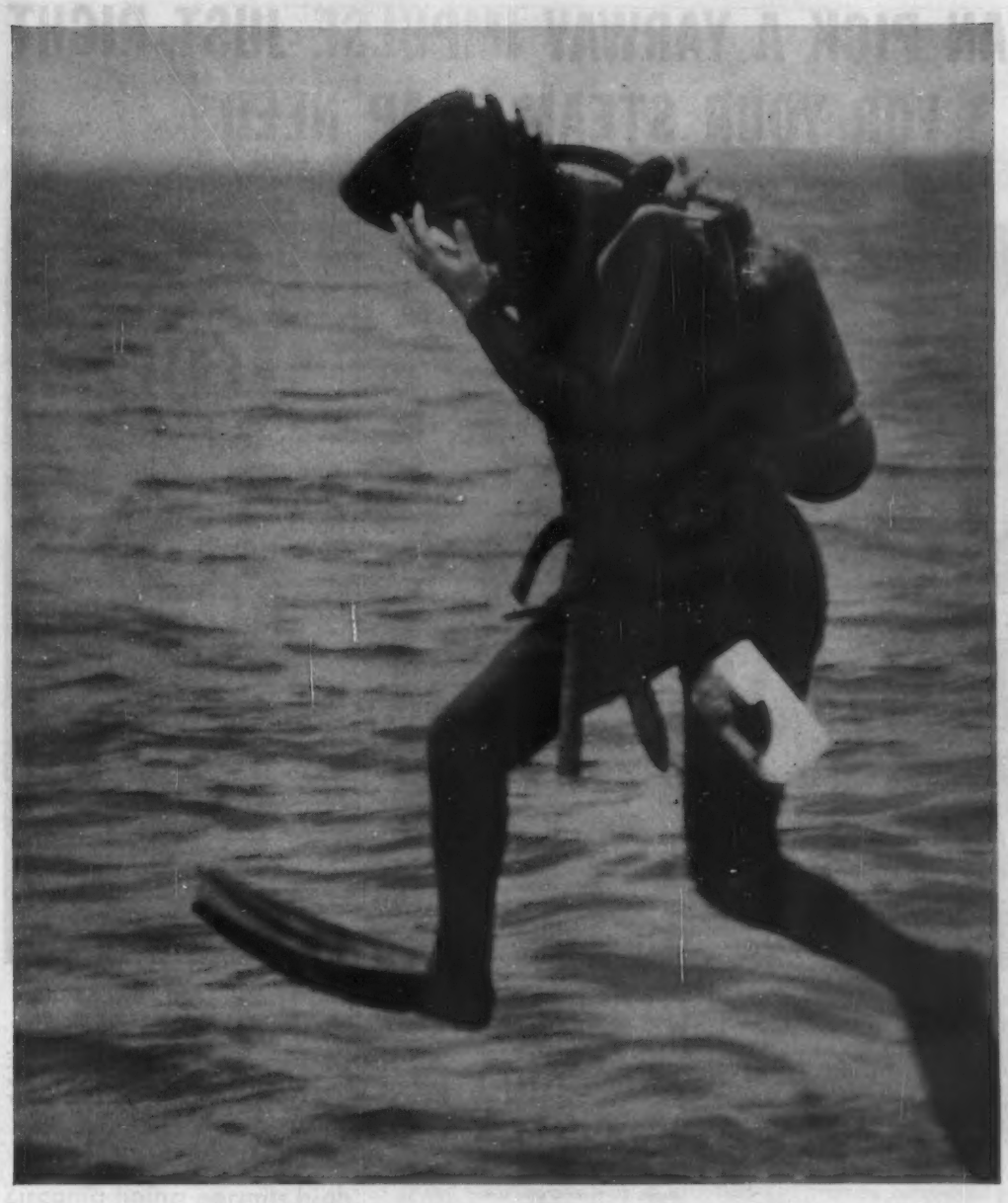
INDICATORS
RECORDERS
CONTROLLERS

for

air weight
btu
capacitance
compression
concentration, solution
conductivity, solution
consistency
current—a-c, d-c
density
dew point
displacement
drag
flow
force
gas analysis
humidity
liquid analysis
liquid level
load
moisture content
motion
motor load
operation, schedule
operation, time
oxidation-reduction potential
pH
position
power, electric
pressure
resistance, electric
sheet moisture
sheet weight
specific gravity
speed
strain
stress
temperature
tension
thrust
torque
vacuum
viscosity
voltage
weight

FOXBORO
REG. U.S. PAT. OFF.

THE FOXBORO COMPANY, 54 NEPONSET AVENUE, FOXBORO, MASS., U. S. A.



MILLION DOLLAR DIVE...

OFF CALIFORNIA a geologist-frogman dives deep to the ocean floor in search of petroleum-bearing rock for Texaco.

If successful, America's oil reserves may be richer by millions of barrels.

On five continents Texaco oil explorers are using aerial surveys, artificial earthquakes, soil analysis and other methods to locate more oil to satisfy the ever-increasing world demand.

This work is just one phase of Texaco's multi-million dollar program to produce more and finer petroleum products for the transportation, rubber, petrochemicals and plastics industries... an investment in the future.

THE TEXAS COMPANY

Progress... at your service

For more data on advertised products, use Readers' Service Cards, last page.

YOU CAN PICK A YARWAY IMPULSE JUST RIGHT FOR YOUR STEAM TRAP NEED

(wide choice of sizes, capacities, pressures and temperatures)

FOR NORMAL REQUIREMENTS

Medium pressures and temperatures—Series 60. Normal condensate loads, pressures 10 to 400 psi, temperatures to 450° F. Six sizes, ½" to 2".

HIGHER PRESSURES AND TEMPERATURES

Normal condensate loads—Series 120; pressures 10 to 600 psi, temperatures to 750° F. Six sizes, ½" to 2".

FOR LIGHT CONDENSATE LOADS

Medium pressures and temperatures—½" No. 20-A; pressures 10 to 400 psi, temperatures to 450° F.

Higher pressures and temperatures—½" No. 120-A (not shown); pressures 10 to 600 psi, temperatures to 750° F.

FOR HEAVY CONDENSATE LOADS

Low, medium and higher pressures and temperatures—Series 40 (lever type); pressures to 600 psi, temperatures to 750° F. Five sizes, ½" to 2½".

FOR POWER PLANT AND MARINE SERVICE

Integral-strainer trap. Normal capacities, pressures to 2500 psi. Six sizes, ½" to 2". Flanged or socket-weld ends.

Already more than 1,225,000 Yarway Impulse Steam Traps have been sold.

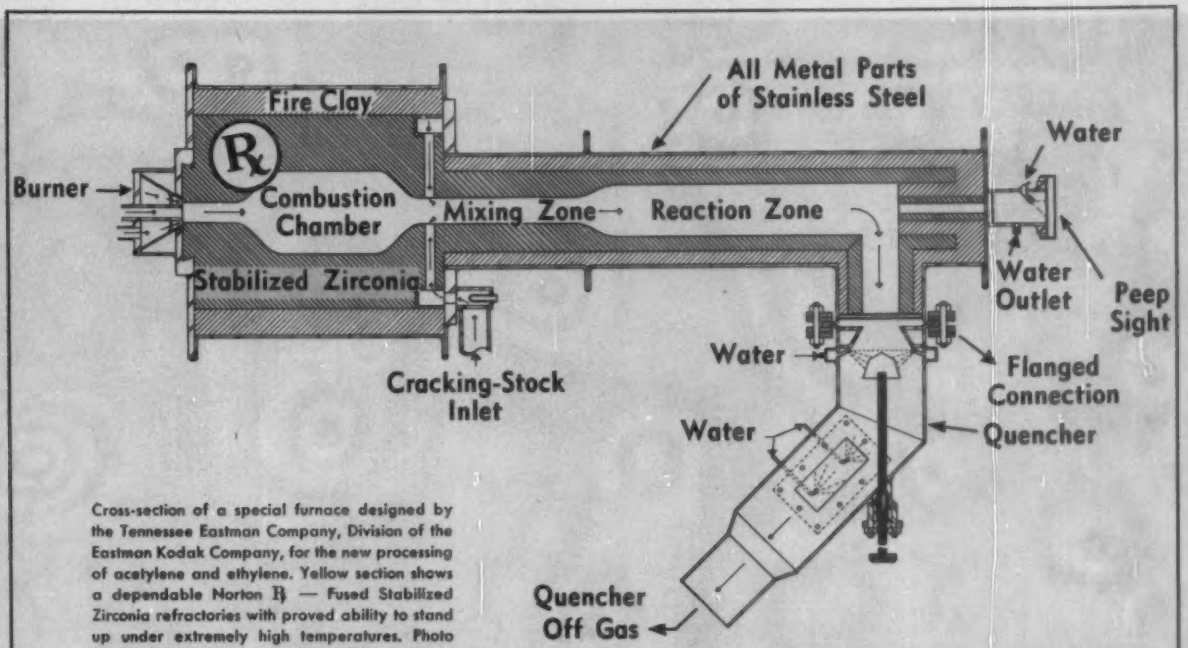
For your convenience—Yarway Traps and Strainers are carried in stock by over 270 industrial distributors all over the world. (Write us for name of the one nearest you.) Try some Yarways in *your* plant and begin to enjoy the improved trap performance many others are experiencing. Prompt steam trap engineering advice and service available to you from our own force of 34 field engineers.

For free booklet "The Why and How of Steam Trapping," write . . .

YARNALL-WARING COMPANY
128 Mermaid Avenue, Philadelphia 18, Pa.

YARWAY impulse® ...a good way to specify steam traps

For more data on advertised products, use Readers' Service Cards, last page.



Cross-section of a special furnace designed by the Tennessee Eastman Company, Division of the Eastman Kodak Company, for the new processing of acetylene and ethylene. Yellow section shows a dependable Norton Rx — Fused Stabilized Zirconia refractories with proved ability to stand up under extremely high temperatures. Photo shows semi-works plant at Kingsport, Tenn., where a year of experimental furnace operation produced 1,000,000 lbs. of acetylene and ethylene — an excellent background for increased commercial production.

New Tennessee Eastman Process uses NORTON Zirconia Refractories

Zirconia lining permits high, uniform heat flux for improved production of acetylene and ethylene.

Heart of Tennessee Eastman Company's advancement in processing acetylene and ethylene is a newly designed furnace. Here, saturated hydrocarbons are decomposed in hot combustion gases. High temperature heat must be supplied rapidly and uniformly. Since an endothermic reaction is involved, a zirconia lining was specified because of its ability to insulate at high temperatures and to conserve valuable heat. This furnace operation required refractories capable of withstanding continuous operation at temperatures in excess of 2,000°C.

Norton Fused Stabilized Zirconia was specified in special shapes for the inner courses of the combustion chamber, mixing zone and reaction zone. As a result, the structural stability and suitability of the furnace for continuous use was confirmed when the combustion chamber was found to be in excellent condition after 100 days of operation.

The development of Fused Stabilized Zirconia is a typical Norton aid in utilizing higher temperatures for greater efficiency and output. Norton was first to bring this valuable material out of the experimental stage. Now it is used in many forms for commercial production.

Investigate Norton Rx's — refractories *engineered and prescribed* to save time, work and money. See your Norton Representative or write to NORTON COMPANY, Refractories Division, 464 New Bond St., Worcester 6, Massachusetts.

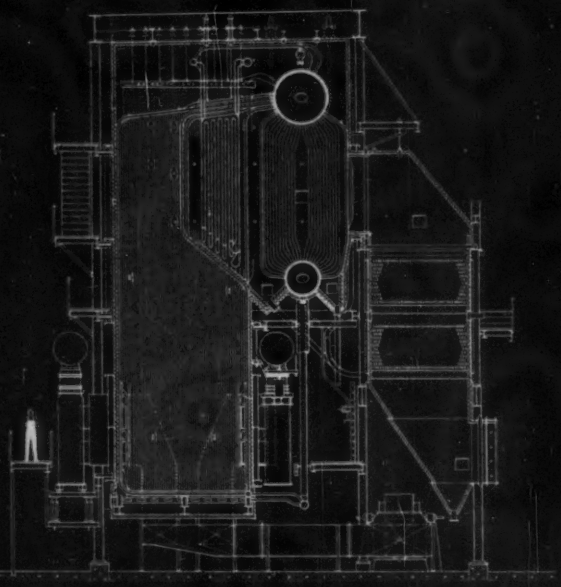
NORTON
REFRACTORIES
Engineered... Rx ...Prescribed

Making better products . . . to make your products better

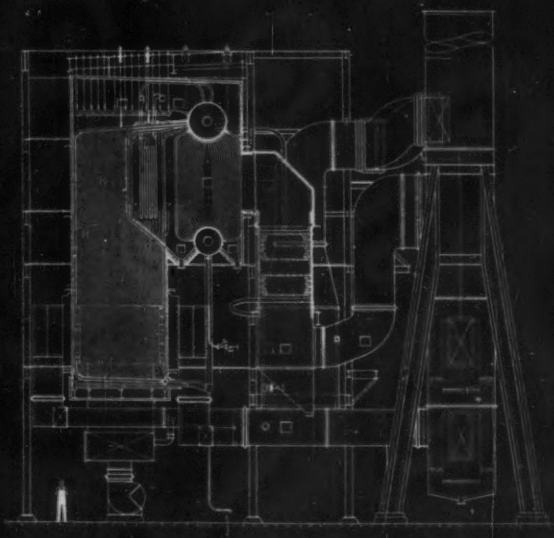
NORTON PRODUCTS Abrasives • Grinding Wheels • Grinding Machines • Refractories • Electrochemicals — BEHR-MANNING DIVISION Coated Abrasives • Sharpening Stones • Pressure-Sensitive Tapes

For more data on advertised products, use Readers' Service Cards, last page.

This unit delivers 175,000 lb of 750F steam per hour at 650 psig. In addition to CO gas, it burns pitch, refinery gas and Bunker C oil.



One of two CO boilers for a Texas refinery. Oxygen for combustion is supplied by the exhaust from the gas turbines which drive the regenerator compressors. Steam conditions are 177,000 lb per hr, 625 psig and 700F.



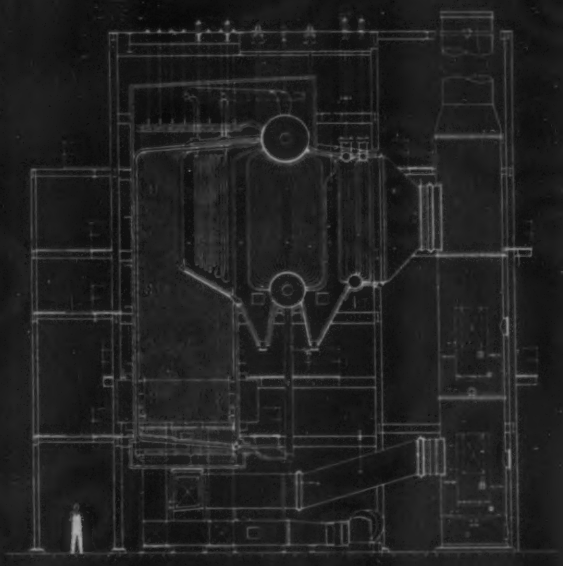
IF YOU'RE LOOKING FOR THE BEST CATALYST REGENERATOR GAS

Here are 8 reasons why

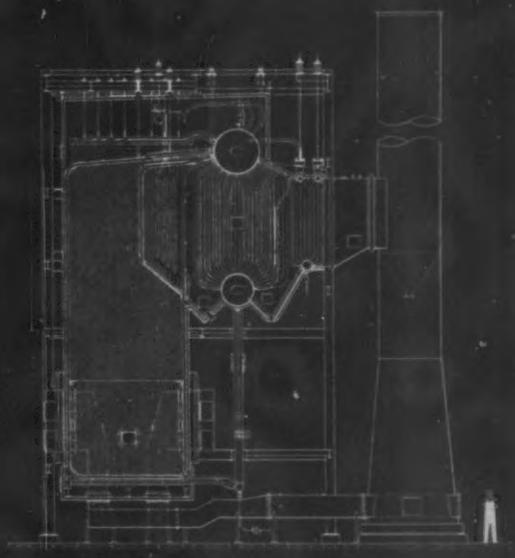
1. **YOU'LL WANT HIGH AVAILABILITY**
   And the records show that the first CO Boiler placed in service by C-E has been on the line for more than two years without a single unscheduled boiler outage.
2. **YOU'LL WANT OPTIMUM RETURN**
   And CO Boilers by C-E burn regenerator gas efficiently *from minimum to maximum loads.*
3. **YOU'LL WANT LOW POWER CONSUMPTION**
   And CO Boilers by C-E provide minimum air pressure loss and minimum fan horsepower requirements.
4. **YOU'LL WANT LOW MAINTENANCE**
   And double steel, skin cased CO Boilers by C-E contain a minimum of exposed refractory.
5. **YOU'LL WANT THE MOST EFFECTIVE USE OF MATERIALS**
   And C-E makes optimum use of boiler and superheater – gas passage areas and heating surfaces are uniformly distributed across the width of the unit.
6. **YOU'LL WANT ADVANCED DESIGN**
   And C-E Tangential Burners provide complete and positive mixing of air, auxiliary fuel and CO gas, preparing the combination for instantaneous ignition on injection in the furnace.
7. **YOU'LL WANT MAXIMUM CONTROL OF THE COMBUSTION PROCESS**
   And CO Boilers by C-E offer individual, shielded cut-off dampers for each CO gas burner and individual air control for every burner.
8. **YOU'LL WANT A PRODUCT THAT HAS PROVEN ITSELF**
   In terms of general experience, a total of more than 675 tangentially fired C-E boilers have been purchased to date for use with various fuels. As to specific experience with lean fuels, C-E – in addition to its CO Boiler installations in refineries – has installed more than 150 boilers burning blast furnace gas . . . a fuel similar to CO gas with a heating value of about 80 Btu per cubic foot.

ALL TYPES OF STEAM GENERATING, FUEL BURNING AND RELATED EQUIPMENT; NUCLEAR REACTORS;

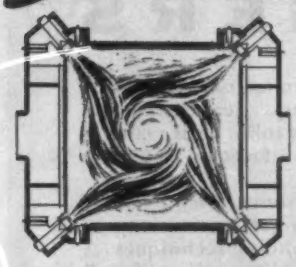
This unit is designed to produce 85,000 lb of 750F steam per hour at 625 psig. Note the C-E seal tank arrangement in the bottom-supported stack.



In its third year of service, this unit provides 100,000 lb of 550F steam per hour at a pressure of 250 psig. It has been off the line only when the cat cracker was removed from service for scheduled maintenance.

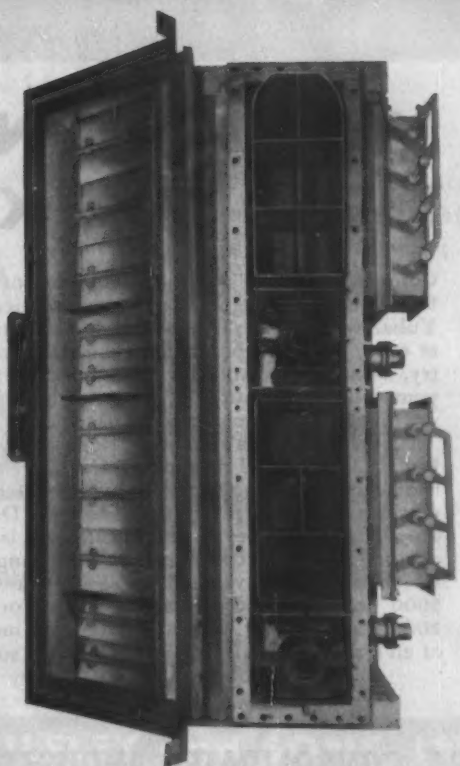


BOILER TO BURN *See* C-E



Plan view diagram showing principle of tangential firing in a completely water-cooled furnace.

The C-E Tangential Burner for CO gas. Zone controlled, dampered air inlets are shown at left, dampered CO gas inlets at right. The center panel is a furnace view of the burner The oil burners in the center and bottom compartments are flanked by flat head burners for natural or refinery gas firing. CO gas is admitted through the other ports.



COMBUSTION ENGINEERING

C-148

Combustion Engineering Building
200 Madison Avenue, New York 16, N. Y.

PAPER MILL EQUIPMENT; PULVERIZERS; FLASH DRYING SYSTEMS; PRESSURE VESSELS; SOIL PIPE

YUBA ENGINEERED HEAT EXCHANGERS

Complete facilities for the production of the finest heat exchangers are at your service at Yuba. With branch offices and representatives at every principal point throughout the country, Yuba is able to have a sales-engineer at your desk in a matter of hours to help you start your heat exchanger project.

At three of Yuba's plants at Honesdale, Pa., Buffalo, N. Y., and Richmond, Calif., are top heat exchanger engineers with national reputations for their progressive designs. Daily they design all types of heat exchangers, large or small, simple or complex... heat exchangers which operate at vacuum or to pressures of 5000 psi, at temperatures below zero or to 1000 F and higher . . . heat exchangers made of all kinds of metals: carbon steel, alloy steel, aluminum, nickel, and non-ferrous alloys such as the new silicon bronzes... heat exchangers with bundles having a few tubes or as many as 7500, with heat transfer surfaces up to 15,000 and 20,000 sq. ft.

Yuba is experienced... some of its divisions having made heat exchangers for as long as 50 years. Yuba has outstanding techniques... many of its heat exchangers having been "firsts" in their fields. Yuba is nationally recognized... in the chemical, oil, gas, power, mechanical and heating industries.

Buy Yuba. Its plants in both the East and the West mean convenience for you, speedy delivery, service . . . but, above all, well-engineered heat exchangers tailor-made for your own process.

YUBA CONSOLIDATED INDUSTRIES, INC.

351 CALIFORNIA STREET, SAN FRANCISCO 4, CALIFORNIA

Divisions Manufacturing Heat Exchangers

ADSCO DIVISION, BUFFALO, N. Y.
CALIFORNIA STEEL PRODUCTS DIVISION, RICHMOND, CALIF.
YUBA HEAT TRANSFER DIVISION, HONESDALE, PA.
YUBA MANUFACTURING DIVISION, BENICIA, CALIF.

YUBA

San Francisco Sales Office:
351 California Street
San Francisco, Calif.

New York Sales Office:
330 Fifth Avenue.

Here are the acid pumps with built-in economy

WILFLEY
ACID PUMPS

- Continuous, Trouble-Free Operation
- Lower Pumping Costs
- Lower Maintenance Costs
- Longer Pump Life
- Higher Output

Wilfley Acid Pumps are available with pumping parts of the machinable alloys as well as plastic to meet all requirements.

Individual Engineering on Every Application

Wilfley Sand Pumps "Companions in Economical Operation" Wilfley Acid Pumps

Write, wire or phone for complete details.

A. R. WILFLEY and SONS, INC.
DENVER, COLORADO, U.S.A. - P.O. BOX 2330
NEW YORK OFFICE: 122 EAST 42ND STREET
NEW YORK CITY 17

One of a series.

Some Things to Think About Steam Traps

...in order to get high operating efficiency and a minimum of maintenance

The gentleman who invented the wheel had a basic idea and so far no one has come up with anything better for the purpose.

If you'll pardon us for a little overemphasis on the significance of steam traps, we'd like to liken one of them to the wheel.

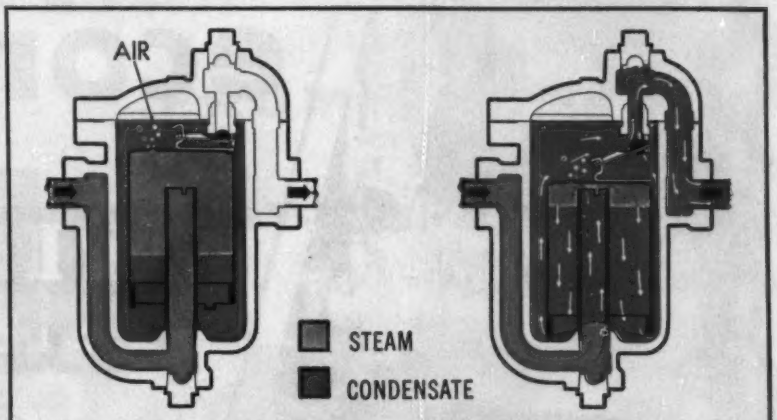
In 1911, when the first Armstrong inverted bucket steam trap model was announced to the world, or at least that part of the world that modest advertising and sales budgets would cover, it was not received with equal enthusiasm by all (especially old-style trap makers). But, like the wheel, it managed to find its way into general use. And, nothing better has ever turned up for the purpose of draining condensate. As a matter of fact, the Armstrong trap has been very widely copied. Today, there are more inverted bucket traps draining process equipment than any other kind. Of these, there are more Armstrongs.

If this sounds like the boasting of a proud parent, give consideration to some fundamental requirements not met by all traps:

1. ***A steam trap should not leak steam.*** Some traps do, you know, because of the nature of their operating principle. No steam ever gets to the Armstrong trap orifice. The valve is always water sealed.

2. ***A steam trap should vent "air" as fast as it accumulates***—otherwise temperatures are reduced and corrosion is a problem. The Armstrong trap handles air very nicely. The vent in the bucket permits air to accumulate in the top of the trap, from where it is discharged when the trap opens. For extreme conditions like draining paper machine dryers, some jacketed kettles and certain other units, the vent is sized larger for the job. And, for handling big volumes of air during warm-up, a bucket with an auxiliary thermic vent really speeds up heating.

3. ***A steam trap should discharge condensate at steam temperature*** if you want to get maximum efficiency from the unit drained. And most people certainly do. If you have to wait for the condensate to cool, it's almost impossible to maintain maximum temperatures and prevent air build-up. You guessed it—the Armstrong trap opens for water, without dependence on temperature.



Trap closed. Steam has floated inverted bucket; valve is held tightly closed by system pressure. Air entering trap passes through bucket vent and accumulates at top of trap.

Trap open. Condensate entering trap has caused bucket to lose buoyancy. Weight of bucket times leverage pulls valve open. Air is discharged along with condensate.

4. ***A steam trap should be suitable for any return system.*** The Armstrong trap works just the same whether discharging to atmosphere, back pressure or vacuum. It has been conclusively proved that flash steam resulting from use of a bucket trap does not cause a problem in vacuum return systems. The flash condenses rapidly. It's the leaky traps that cause the headaches.

5. ***A steam trap should not be a "prima donna".*** Some kinds of traps take an awful lot of care and coddling. The Armstrong trap is a rough and ready type with a hardened chrome steel constitution (valve and seat, to be exact). It cleans itself of ordinary dirt and scale without choking up. Its 18-8 stainless parts stave off rust and corrosion. It resists wire-drawing and wear remarkably well. In fact, it stays on the job longer with less attention than any trap ever produced. Unless you live in Siberia, you can probably find a user around the corner who will tell you so from experience.

6. ***A trap should not be an "orphan".*** With Armstrong traps you can *always* get prompt service and parts from nearby Factory Representatives and stocking distributors as well as from the factory.

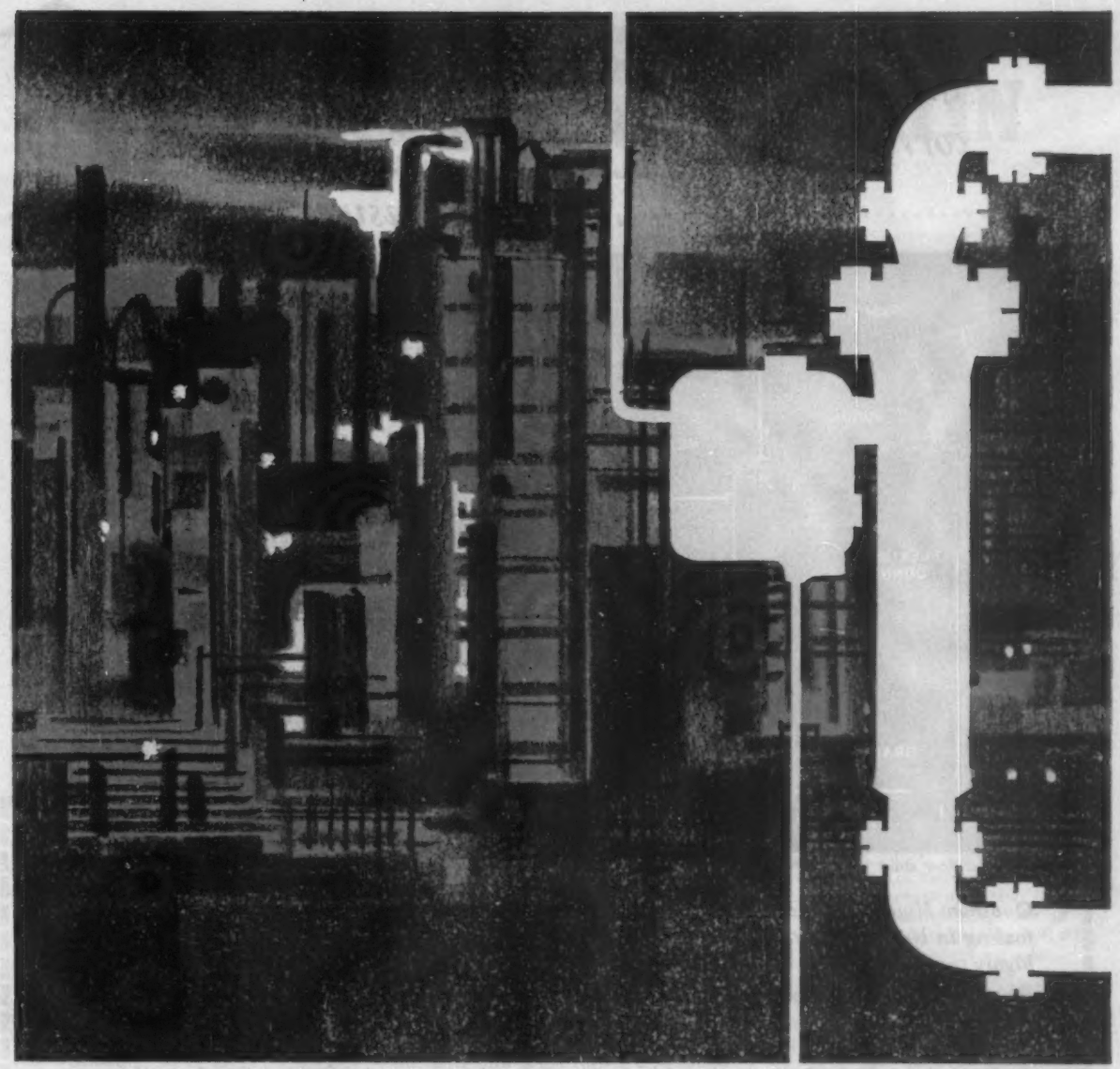
7. ***A trap should have a guarantee.*** The Armstrong trap is unconditionally guaranteed to give you *complete satisfaction* (as to doing its job, that is). If it doesn't, you can get your money back.

If you'd like to buy some of these excellent steam traps, call your local Armstrong Representative or write. **Armstrong Machine Works, 8523 Maple St., Three Rivers, Michigan.**

ASK FOR the 44-page Steam Trap Book, free on request without obligation.

ARMSTRONG STEAM TRAPS

For more data on advertised products, use Readers' Service Cards, last page.



Fisher Level-Trols—universally accepted in the power and process industries

High in sensitivity and accuracy! For full float range operation the Fisher Level-Trol is factory calibrated or zero adjusted to produce an accurate 3 to 15 psi or 6 to 30 psi signal output. Designed, engineered and universally accepted for most liquid level control, liquid level indication and interface control problems. Has simple liquid level adjustment indicating dial—combined pneumatic proportional band and specific gravity adjustment. Heavy-duty built—easy to operate—simple to service. Available with cage units for external mounting or internal top or side flange mounting with float sizes from 14″ to 120″.

Write for Bulletin F4A for full details.

IF IT FLOWS THROUGH PIPE ANYWHERE IN THE WORLD... CHANCES ARE IT'S CONTROLLED BY...

FISHER GOVERNOR COMPANY

Marshalltown, Iowa / Woodstock, Ontario / London, England

FISHER® Controls

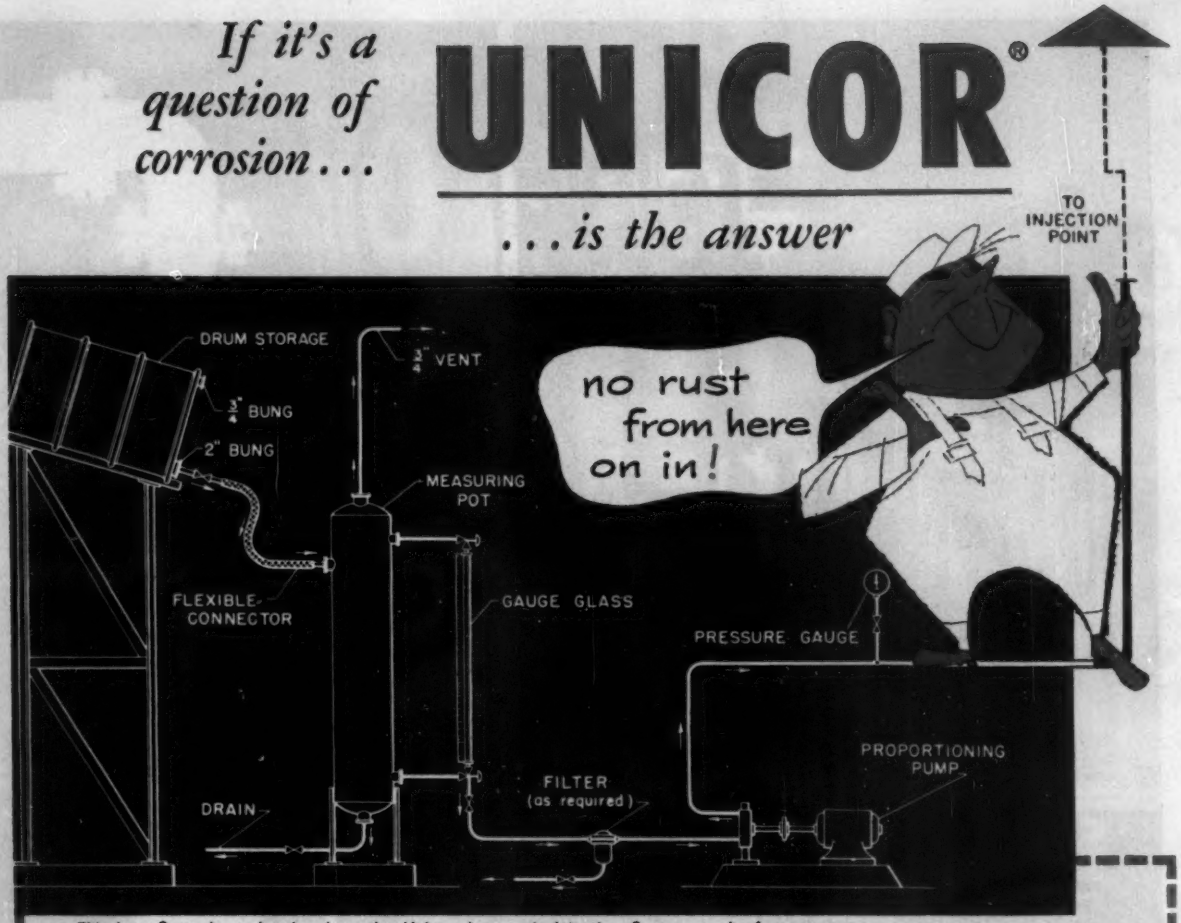
SINCE 1880

For more data on advertised products, use Readers' Service Cards, last page.

If it's a question of corrosion...

UNICOR®

...is the answer



This is a flow chart showing how the Unicor Automatic Injection System works for you.

Question: *How can we eliminate serious filter fouling in blending tank caused by formation of highly peptized iron rust during processing?*

Answer: UOP's Unicor corrosion inhibitor solved this problem for a large southern refiner not long ago. Before Unicor application, a yard-square panel of the tank interior was sandblasted down to bare metal to test Unicor's effectiveness. After several months of injection in the rundown line, this test panel was completely free of corrosion, the remainder of tank interior was free of filter-fouling rust.

Question: *Is addition of water necessary?*

Answer: No. Unicor is oil soluble. It also prevents rusting caused by unavoidably entrained or dissolved moisture.

Question: *Should Unicor be injected only in the rundown line?*

Answer: Unicor can be injected at any point in your process. The refiner mentioned above shifted the Unicor injection point from the rundown line to his crude fractionator overhead and in catalytic gasoline from the main column overhead receiver. This extended Unicor's protection to heat exchangers, condensers and towers between new injection points and blending tank. Unicor inhibits corrosion in all your processing equipment from the point of injection on... even to consumer equipment.

Question: *How much does Unicor cost?*

Answer: About $0.001 or a tenth of a cent per bbl. of product in normal application.

Let us send you samples of

UNICOR

for testing in your own laboratories.

UOP®

UNIVERSAL OIL PRODUCTS COMPANY
30 ALGONQUIN ROAD
DES PLAINES, ILLINOIS, U.S.A.

For more data on advertised products, use Readers' Service Cards, last page.

BRIDGEPORT BRASS

COPPER ALLOY BULLETIN

CONDENSER AND HEAT EXCHANGER TUBE EDITION

Advantages of Duplex Tube

by C. L. BULOW
Chief Corrosion Metallurgist
Bridgeport Brass Company

Bridgeport Duplex Tubes are used where a heat exchanger tube is attacked simultaneously inside and out by different types of corrosive media. Duplex is made by drawing two tubes of different metals, one over the other, and combining them into a single tube.

Metal Combinations

This type of construction permits the use of a wide range of combinations of metals—Admiralty, Cupro Nickel, Copper, Aluminum Brass, and many others coupled with steel, nickel, aluminum, stainless steel, Monel, etc.

Many Uses

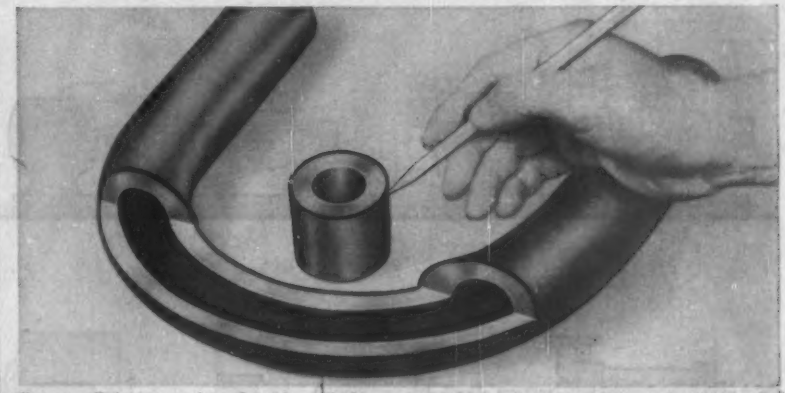
Applications for Bridgeport Duplex Tubes include successful service in the production of ammonia, benzol, hydrocarbons, resins, rubber chemicals, carbon dioxide and many other chemicals. Likewise, duplex tubes are admirably suited for replacement of ordinary boiler tubes for use in air-compressor aftercoolers, lube-oil coolers and fuel-oil heaters.

Applying Duplex Tubes

It is virtually impossible to prescribe what duplex tube combination is best for any specific use without information on the specific requirements of the application. The important point to remember is that with duplex tubes you can practically "tailor" the tube to your requirements.

Laminated Tube Sheets—Another Weapon In The Fight Against Dual Corrosion

Bridgeport now offers metallurgically bonded dual-metal tube sheets especially designed to combat dual corrosion. These tube sheets are a valuable adjunct to duplex and copper and copper-alloy condenser and heat exchanger tubes. They are available in a number of combinations such as Naval Brass, Muntz Metal, silicon bronze, copper, and Monel with steel and stainless steel.



Heavy-wall duplex consists of a thin wall of copper or other nonferrous metal around a thick-walled steel tube—a perfect combination for high pressures and utmost corrosion resistance.

New Bridgeport Heavy-Wall Duplex Tubes Lick Dual Corrosion Problems at High Pressures

High-pressure heat exchanger operation presents two very basic problems. The first is to find a tube thick enough to stand up under the pressures used. The second is to find a tube material able to withstand corrosive attack for long periods of time and at the same time provide desired heat-transfer characteristics.

New Heavy-Wall Duplex

Bridgeport came up with the answer in a new design—heavy-wall duplex tube. Heavy-wall duplex consists of a heavy inner tube with an outside covering of thin-wall nonferrous tubing. Although the inner tube is low carbon or stainless steel, and the outer tube Cupro Nickel, Red Brass, Admiralty or copper, both inner and outer tube materials can be varied to suit the conditions of the application.

Advantages

Use of a nonferrous outer tube cuts corrosive effects of cooling water. And, because it resists corrosion, it gives the entire tube installation superior heat-transfer characteristics. With proper cleaning and maintenance, a Bridgeport Heavy-Wall Duplex Tube will substantially outperform single metal tubes.

Installation

Most applications are in cascade coolers where bent tube ends are required. Small sections of heavy-wall duplex can be formed to the desired radius or one end of long sections can be bent, thereby eliminating one weld joint.

Heavy-wall duplex tubes are designed to the ASME Code to operate at pressures up to 5,000 psi. They will, however, pass hydrostatic tests at much higher pressures. In actual operation they will give years of satisfactory trouble-free service with no more than normal cleaning and maintenance procedures.

To make hairpin turns, sections of heavy-wall duplex are bent and welded to straight lengths or other bent sections.

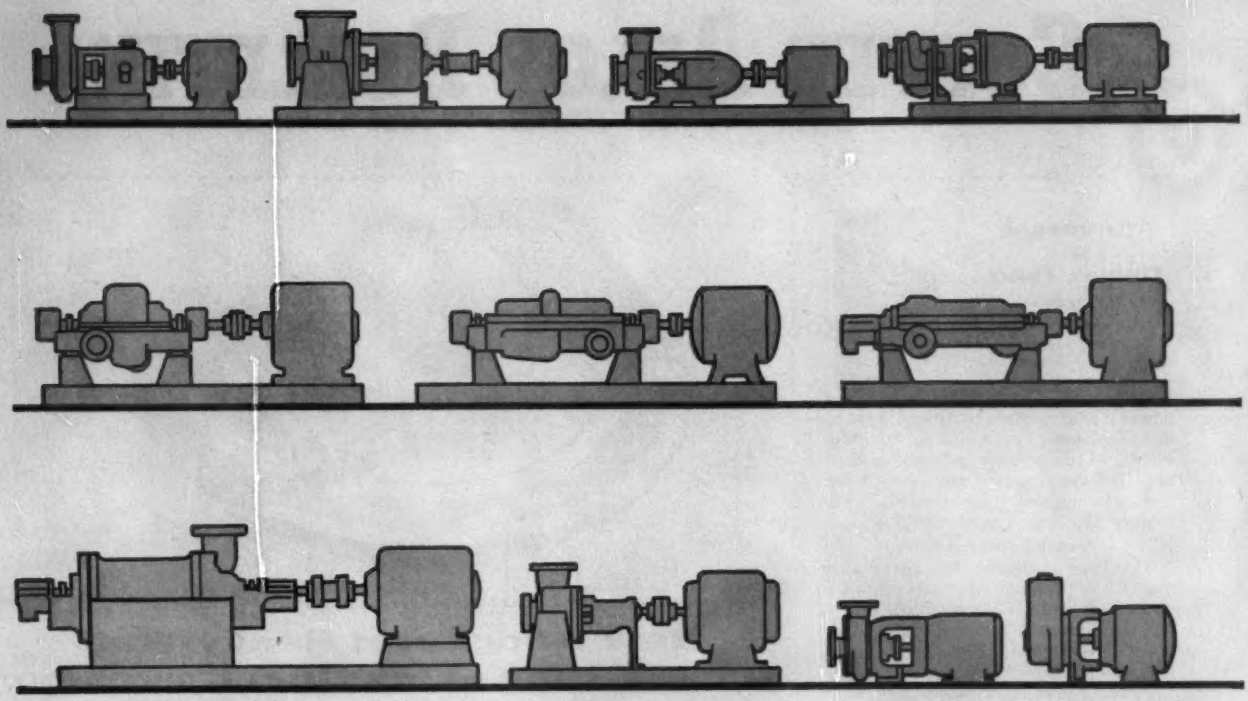
Further Information

More detailed information on sizes, characteristics and ratings of Bridgeport Heavy-Wall Duplex Tubes will be furnished on request. Our Technical Service representatives are also available to cooperate with you in working out application problems. For prompt service, call your nearest Bridgeport Sales Office.

BRIDGEPORT BRASS

Bridgeport Brass Company, Bridgeport 2, Connecticut • Offices in Principal Cities
In Canada: Noranda Copper and Brass Limited, Montreal

For more data on advertised products, use Readers' Service Cards, last page.



Which one is the right pump for

The efficiency of your entire process can depend on the selection of the right process pumps... or even on a single pump.

Here are five questions you should ask yourself about pump manufacturers... know the answers before you select your next pump.

1 *Who has the most complete line?*

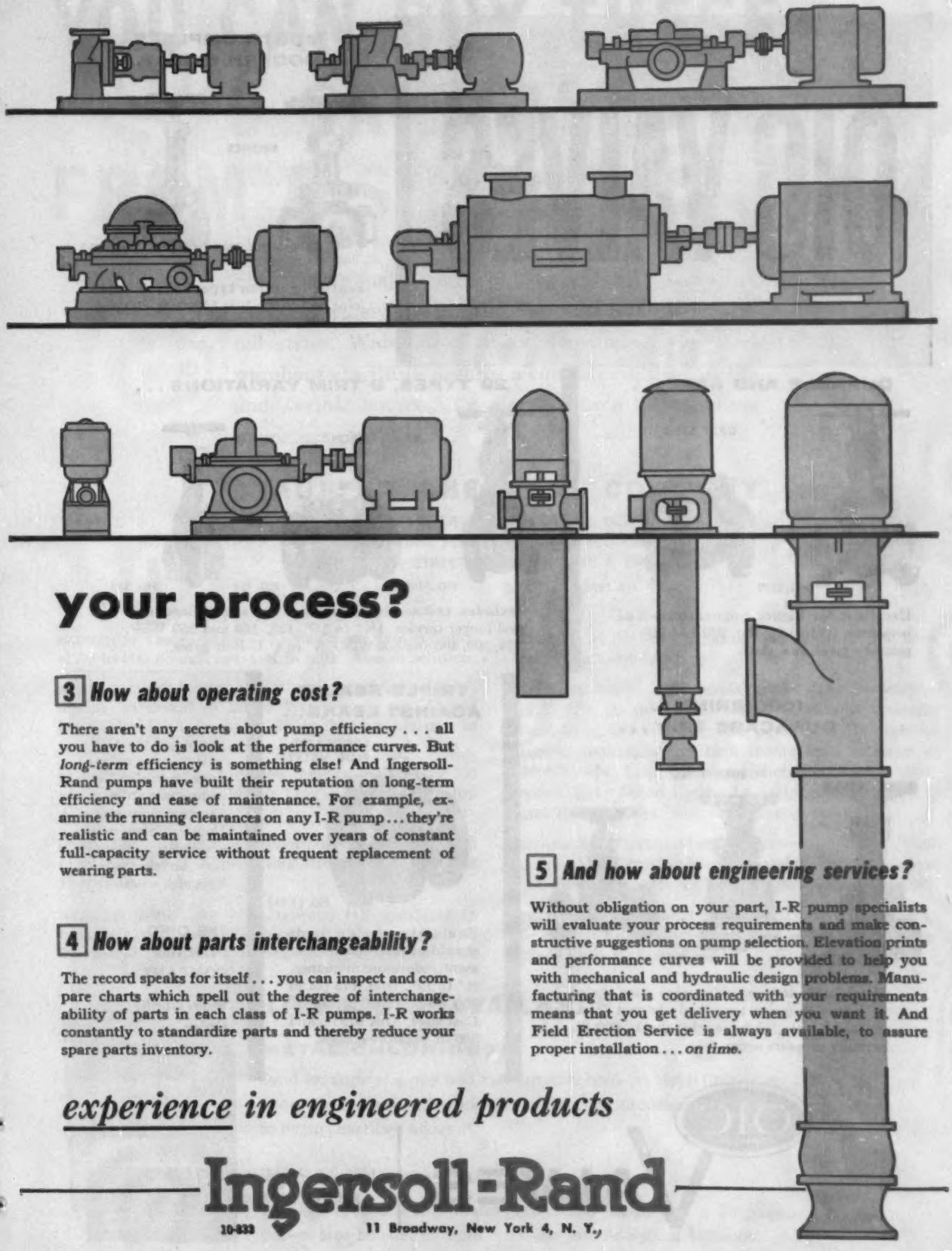
It's a fact that Ingersoll-Rand makes the most complete line of centrifugal pumps available from any single source. Often I-R is the only supplier who can quote on all the centrifugal pumps needed for a new processing plant. For that reason you benefit in two ways: The I-R engineer will be completely unbiased in helping you select the right pumps, and you get the advantages of *undivided responsibility* for all your pump requirements.

2 *What if I need a "special" pump?*

Despite the unequalled completeness of the I-R line (a few of the hundreds of types and sizes are sketched above), there are occasions when a standard pump won't do the job properly. Here's where Ingersoll-Rand's long experience pays off. If the right pump doesn't exist, I-R will build it! This is another reason why you're always sure to get the right pump for the job from I-R.

There's no substitute for

COMPRESSORS · PUMPS · DIESEL ENGINES · AIR & ELECTRIC TOOLS · TURBO BLOWERS · CONDENSERS



your process?

3 How about operating cost?

There aren't any secrets about pump efficiency . . . all you have to do is look at the performance curves. But *long-term* efficiency is something else! And Ingersoll-Rand pumps have built their reputation on long-term efficiency and ease of maintenance. For example, examine the running clearances on any I-R pump . . . they're realistic and can be maintained over years of constant full-capacity service without frequent replacement of wearing parts.

4 How about parts interchangeability?

The record speaks for itself . . . you can inspect and compare charts which spell out the degree of interchangeability of parts in each class of I-R pumps. I-R works constantly to standardize parts and thereby reduce your spare parts inventory.

5 And how about engineering services?

Without obligation on your part, I-R pump specialists will evaluate your process requirements and make constructive suggestions on pump selection. Elevation prints and performance curves will be provided to help you with mechanical and hydraulic design problems. Manufacturing that is coordinated with your requirements means that you get delivery when you want it. And Field Erection Service is always available, to assure proper installation . . . *on time.*

experience in engineered products

Ingersoll-Rand

10-833 11 Broadway, New York 4, N. Y.

For more data on advertised products, use Readers' Service Cards, last page.

OIC VALVES

MOST COMPLETE MODERN LINE...

BRONZE

FIG. 520

FIG. 7100

Featuring union type, body-bonnet joint. ⅛" to 3". 125, 150, 200, 300 and 350 WSP; 200 to 2,500 WOG.

DURABLE AND SAFE...

CAST STEEL

FIG. 3002

FIG. 1572

Excellent for higher temperatures and pressures. 2" to 16". 150, 300 and 600 lb. primary pressure series.

29 TYPES, 9 TRIM VARIATIONS...

IRON

FIG. 1140

FIG. 124

FIG. 333

Includes end-seated seat rings for streamlined flow and longer service. 1¼" to 16". 125, 150 and 250 WSP; 175, 200, 400 and 500 WOG. ¼" to 4" U-Bolt gates.

1000 BRINELL DURACASE TRIM...

FORGED STEEL

FIG. 1021

FIG. 1321

FIG. 1720

Extra-hard, duracase trim, plus your choice of bolted or union type, body-bonnet joint. ¼" to 2" gate, globe, angle, check; 600 lb. primary pressure series.

TRIPLE-SEALED AGAINST LEAKS...

LUBRICATED PLUG VALVES

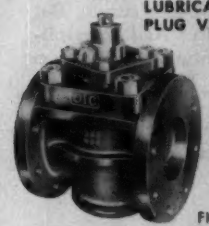


FIG. CR-212

Exclusive design ends shank leakage, holds adjustment, reduces maintenance. ½" to 12". Iron, 175 psi to 800 psi working pressures. Cast steel, ASA 150 lb. and 300 lb. pressure classes.

Write for the OIC valve cross reference booklet. It compares valves of 15 manufacturers. Request also new specification literature on the valve lines of your choice.

THE OHIO INJECTOR COMPANY

Wadsworth, Ohio

OIC VALVES

FORGED & CAST STEEL, LUBRICATED PLUG, BRONZE & IRON VALVES

For more data on advertised products, use Readers' Service Cards, last page.

YOU CAN BUY THESE 9 CATALYSTS FROM A SINGLE SOURCE!

Stauffer is a major source of metal chlorides and other catalysts widely used in the Petroleum and Chemical industries. Wide distribution of manufacturing and warehouse facilities assures a continuous, dependable and *flexible* source . . . a *single* source for all these important catalysts.

STAUFFER CHEMICAL COMPANY

380 MADISON AVENUE, NEW YORK 17, NEW YORK
PRUDENTIAL PLAZA, CHICAGO 1, ILLINOIS
636 CALIFORNIA STREET, SAN FRANCISCO 8, CALIFORNIA

ALUMINUM TRICHLORIDE — Various mesh sizes in drums of 50 to 600 pounds net, and in bulk. Also in solution.

ANTIMONY CHLORIDES — Both solid and flake (anhydrous) in drums of 25 to 700 pounds net. Liquid pentachloride in drums of 25 to 700 pounds net, in tank trucks and tank cars.

BORON TRICHLORIDE — In low-pressure cylinders of 100 and 1800 pounds net; also in tank cars. 6-pound cylinders for experimental use.

HYDROCHLORIC ACID — Anhydrous HCl available in tube trailers or cylinders from Richmond, Calif., and Fort Worth, Texas.

HYDROFLUORIC ACID — Anhydrous HF available in tank cars of 22- and 42-ton capacity, and in 100- and 200-pound cylinders, from Stauffer's Nyotex Chemicals Division at Houston; aqueous acid in drums and tank cars from Louisville.

SULFURIC ACID — Commercial grades at concentrations of 77.67% up to 122.5%. Oleum at various strengths from 15 to 65% free SO_3; also liquid SO_3. By pipeline, barges, tank cars and tank trucks from factories at Mobile, Ala.; Los Angeles and Richmond, Calif.; Hammond, Ind.; Baton Rouge, La.; Baytown, Fort Worth and Houston, Tex., and various stock points.

TITANIUM TETRACHLORIDE — Technical and C.P. Tank cars and tank trucks; 10-gallon and 55-gallon drums of 130 and 725 pounds net from Niagara Falls, New York.

TITANIUM TRICHLORIDE (Anhydrous) — Available in 1-, 5- and 55-gallon drums packaged under argon atmosphere f.o.b. Richmond, Calif.

LITERATURE AVAILABLE

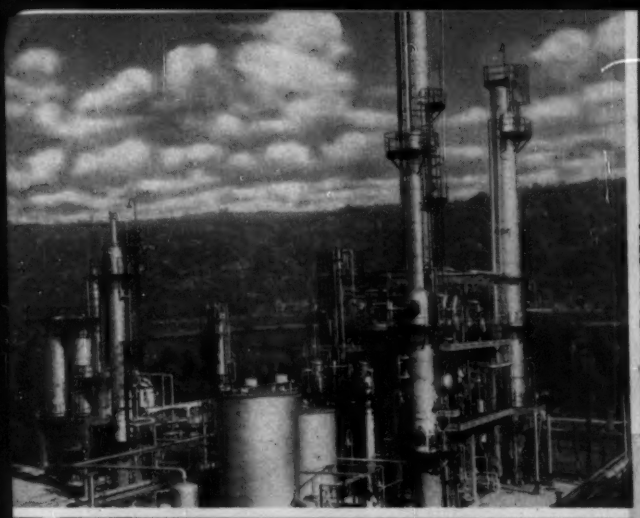
METAL CHLORIDES:

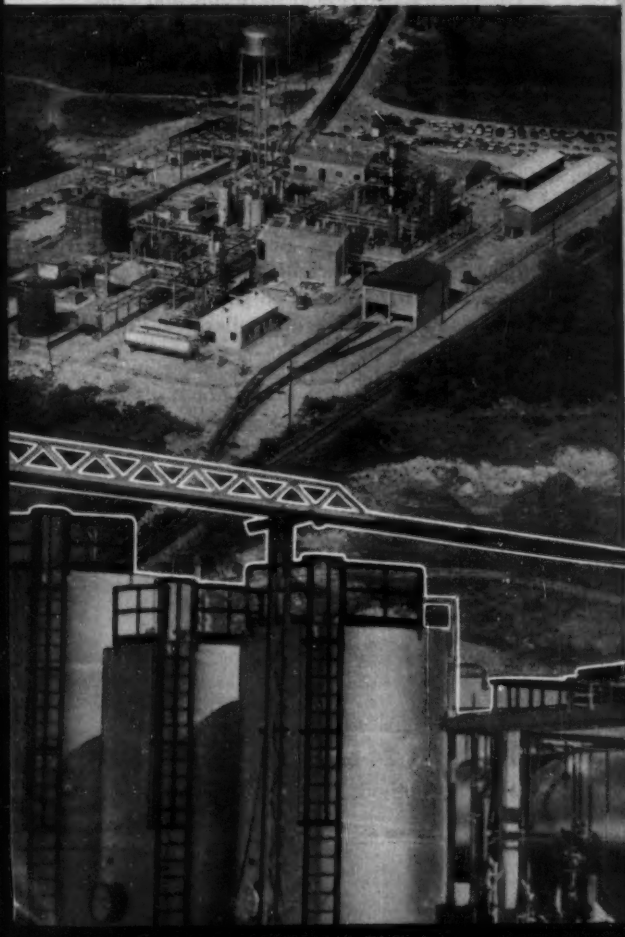
Send for copy of a new and authoritative book on Metal Chlorides. There are sections on chlorides of silicon and zirconium in addition to those described above.

HYDROFLUORIC ACID:

16-page brochure with many graphs and tables and a 24-page pocket-size booklet on Safe Handling and Analytical Methods.

For more data on advertised products, use Readers' Service Cards, last page.





They bring the "tough ones" to Badger

On these two pages are shown a few of the difficult projects successfully completed by Badger during the past year.

They were tough, but we did them. As a result of accomplishments like these, Badger's growth in '57 was double the previous year's.

Now, we think we have earned the right to an easy assignment. *You* have the right to think that if Badger can do the tough ones so well,

Badger can do the easy ones better, too

It's worth investigating — and easy. Key Man Service can be yours in a matter of hours — call or write today!

AIChE

1958—GOLDEN ANNIVERSARY

Congratulations from Badger on 50 years of achievement. All the Directors of Badger Manufacturing Company are Members of the Institute.

BADGER

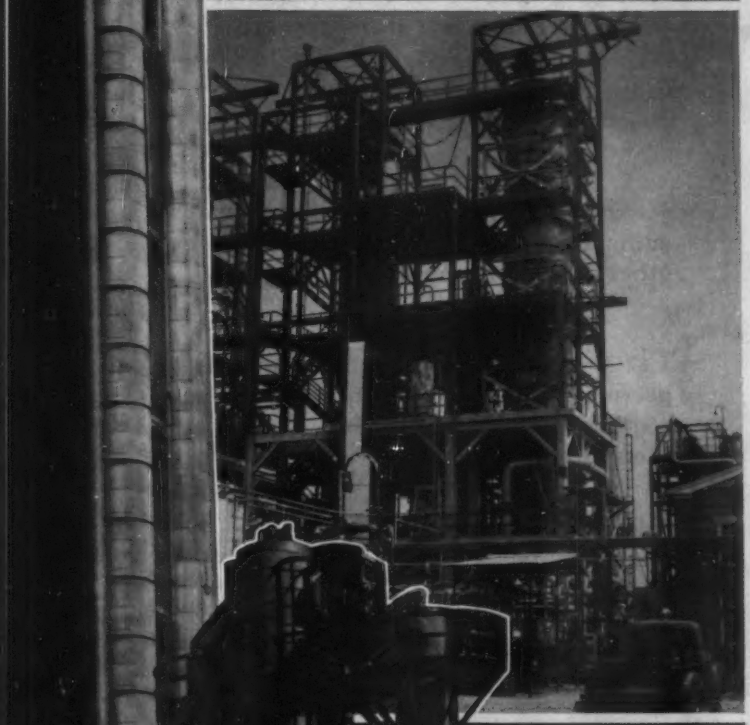
MANUFACTURING COMPANY

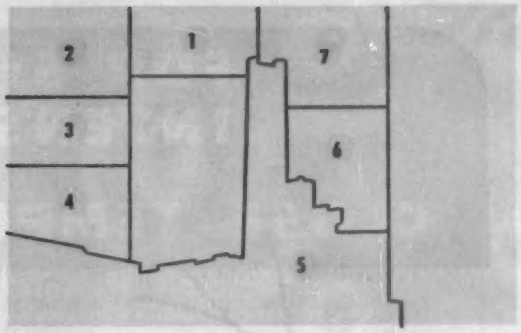
ENGINEERS • CONTRACTORS • DESIGNERS • MANUFACTURERS

230 Bent St., Cambridge, Mass. • New York, N. Y. • Houston, Texas

IN EUROPE: Badger-Comprimo N. V., The Hague

Badger-Comprimo S. A., Antwerp





1 **Columbia-National Corp., Pensacola, Fla.** This plant, engineered and constructed for Columbia-National Corporation, will produce 1,500,000 pounds of hafnium-free Zirconium per year.

2 **Jones & Laughlin Steel Corp., Aliquippa, Pa.** Revolution in coal chemicals! For Jones & Laughlin Steel Corporation Badger engineers came up with a new process application that eliminates the conventional acid-washing step to produce near absolute pure benzene and toluene.

3 **Esso Standard Oil Co., Everett, Mass.** One of three current Powerformer projects being handled by Badger. Unit shown is now producing Golden Esso Extra at Esso's Everett, Massachusetts, refinery. Plant was built completely on "stilts" — piles driven deep into tideland marshes.

4 **Metal Hydrides Inc., Danvers, Mass.** A new plant for the production of Sodium Borohydride, a component of "exotic" fuels. Badger handled the engineering, procurement and construction on this job. Plant was ready in record time even though the process was new and tricky.

5 **Cosden Petroleum Corp., Big Spring, Texas.** Styrene from gasoline! Ultra-fractionation and other pioneering process developments made this "impossible" plant a commercial reality. On stream in February 1957, the plant produced better than plastic-grade styrene right from initial start-up!

6 **Commercial Solvents Corp., Sterlington, La.** More methanol facilities. This unit is one of four built in recent years for Commercial Solvents Corporation. Like all methanol units designed by Badger, no chemical purification step is used, yet the product exceeds all present purity specifications.

7 **Esso Nederland N. V., Rotterdam, The Netherlands.** Model of two process units similar to those being installed in a complete 100,000 bpsd refinery, now under construction in Rotterdam for Esso Nederland N. V. Badger-Comprimo, owned jointly by Badger and Comprimo N. V., The Netherlands, is prime mechanical, engineering and construction contractor.

Other current Badger projects

Propane Deasphalting Unit — Anderson-Prichard Oil Corp., Arkansas City, Kansas • MEK Dewaxing-Deoiling Plant — Atlantic Refining Company, Point Breeze, Pa. • HF Alkylation Unit — Champlin Oil & Refining Company, Enid, Okla. • Sulfuric Acid Alkylation Unit — Chinese Petroleum Corporation, Taiwan, Formosa • Continuous Tar Distillation Plant* — Dominion Tar & Chemical Co., Ltd., Hamilton, Ontario • Powerforming Unit** — Esso Standard Refinery S. A., Antwerp, Belgium • Tall Oil Plant -The Glidden Company, Port St. Joe, Fla. • Benzene Udex Unit– Humble Oil & Refining Company, Baytown, Texas • Tall Oil Plant — Monsanto Chemical Company, Nitro, W. Va. • Methanol Plant — Rohm & Haas Company, Houston, Texas • MEK Dewaxing-Deoiling Plant — Sinclair Refining Company, East Chicago, Ind. • Vacuum Distillation Unit — Sinclair Refining Company, East Chicago, Ind. • Paraxylene Plant — Sinclair Refining Company, Houston, Texas • Xylene Udex Unit — Sinclair Refining Company, Houston, Texas.

**Project of Canadian Badger Company Limited*
***Project of Badger-Comprimo N.V., The Netherlands*

FOR SIMULTANEOUS INTENSIVE MIXING *and* CLOSE TEMPERATURE CONTROL

★**A dominant factor in alkylation** through production of better alkylate with less catalyst consumption and other economies.

★**Widely used in grease making** to produce a more uniform soap with shorter time cycles and reduced manpower requirements.

★**A leader** in new fields of continuous sulfonation, lube oil treating and for other contacting purposes.

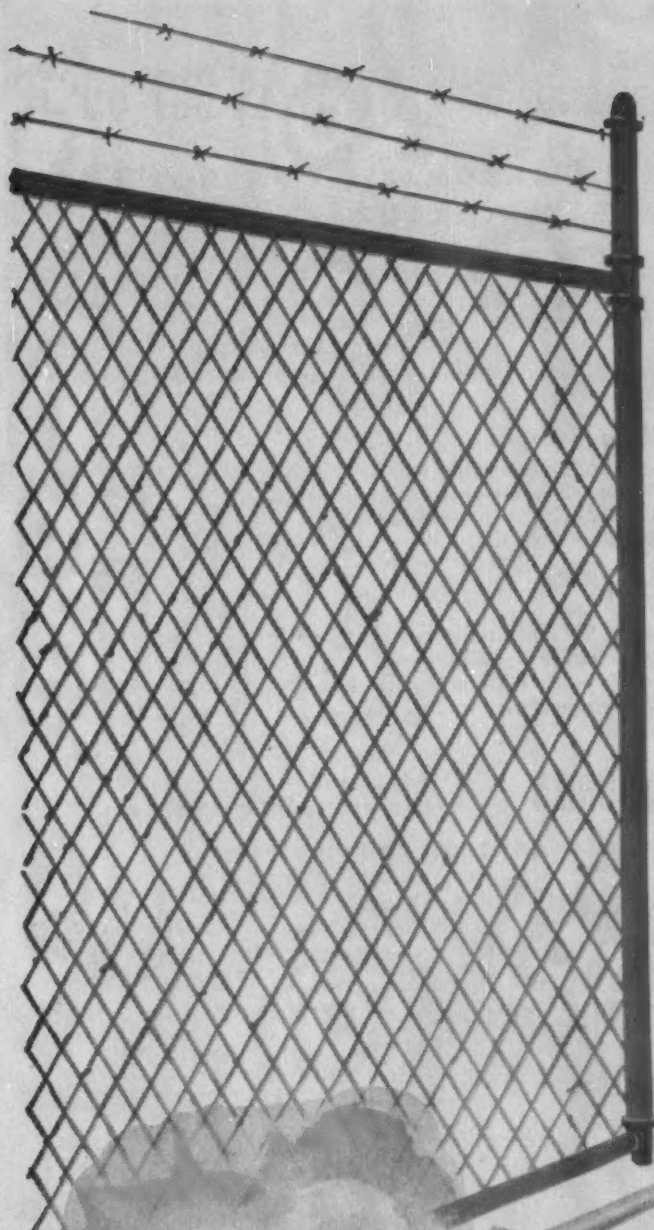
★**The answer** to many "unsolvable" petrochemical and chemical problems requiring close temperature control in the reactor.

Stratco Contactors may be designed for almost any degree of mixing short of homogenization. With internal heat transfer surface they provide extremely close control of temperature throughout the entire liquid volume of the contactor. The reacting liquids are maintained in the desired degree of dispersion throughout their residence time, and residence time may be varied to suit the problem. Stratco Contactors are available in sizes from 300 cc volume laboratory units up to 11000 gallon volume or larger commercial sizes.

• ***They are adaptable to your process problems . . . large or small***

REPRESENTATIVES
D. D. Foster Co., Pittsburgh — Rawson & Co., Houston and Baton Rouge
Lester Oberholtz, Los Angeles — F. J. McConnell Co., New York

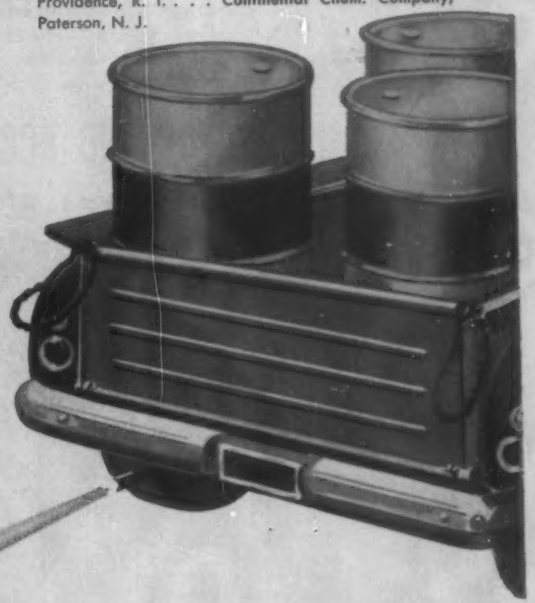
STRATFORD ENGINEERING
Corporation
612 West 47th St. — PETROLEUM REFINING ENGINEERS — Kansas City 12, Mo.



Wherever you are, there's a distributor of Nitrogen Division ethanolamines and ethylene glycols nearby. Why not make a note right now of the one nearest you.

Local stocks of ethanolamines and ethylene glycols are maintained by the following Nitrogen Division distributors for serving the oil and gas industry:

Los Angeles Chemical Company, South Gate, Calif. . . . **Cole & De Graff,** San Francisco, Calif. . . . **Mine & Smelter Chemical Company,** Denver, Colo. . . . **Acid Products Company, Inc.,** Chicago, Ill. . . . **Mid Continent Chemical Company,** South Bend, Ind. . . . **Coastal Enterprises, Inc.,** Abbeville, La. . . . **Southwest Gas Equipment Company,** Liberal, Kans. . . . **Thompson-Hayward Chemical Company in:** Des Moines, Iowa; Wichita, Kans., Shreveport, La.; Oklahoma City, Okla.; Tulsa, Okla.; Dallas, Tex.; Houston, Tex.; Lubbock, Tex.; San Antonio, Tex. . . . **Dyce Sales & Engineering Service Co.,** Billings, Mont. . . . **Harry A. Baumstark & Co.,** St. Louis, Mo. . . . **Aetna Color & Chemical Co.,** E. Paterson, N. J. . . . **George S. Coyne Chemical Company,** Philadelphia, Pa. . . . **T. H. Baylis Company,** Providence, R. I. . . . **Continental Chem. Company,** Paterson, N. J.



GET *FAST DELIVERY* ON ETHANOLAMINES AND ETHYLENE GLYCOLS — ANYWHERE!

Allied Chemical

Ethanolamines • Ethylene Oxide • Ethylene Glycols • Urea • Formaldehyde • U. F. Concentrate—85 • Anhydrous Ammonia • Ammonia Liquor • Ammonium Sulfate • Ammonium Nitrate • Sodium Nitrate • Methanol • Nitrogen Solutions • Nitrogen Tetroxide • Fertilizers & Feed Supplements

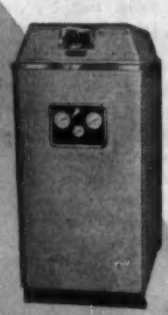
Nitrogen Division • Department GA 2-22-3 • 40 Rector Street, New York 6, New York

For more data on advertised products, use Readers' Service Cards, last page.

HOW BOWSER Liquid Handling SYSTEMS CUT COSTS

WITH AUTOMATIC CONTROL AND GREATER ACCURACY

Automate your metering, batching or blending operation with a Bowser liquid control SYSTEM . . . and get these BENEFITS . . . lower initial investment . . . completely automatic control . . . unsurpassed accuracy . . . increased efficiency . . . single source of supply . . . and system performance guaranteed by Bowser, Inc.

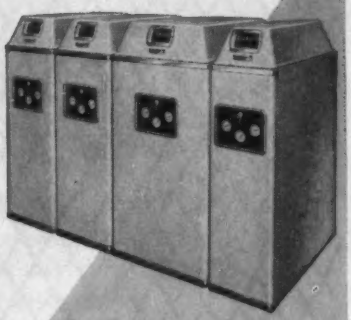


Rate of Flow Controlling System

The Figure 417 Rate of Flow Controller is a completely self-contained system enabling fully automatic and accurate CONTROL of the rate of liquid in flow . . . to better than ¼ of 1% accuracy. Handles flow rates from ½ G.P.M. to 250 G.P.M.

Liquid Blending System

The Figure 413 Precision Blending System automatically and accurately blends two or more liquids in closed, continuous production. Accuracy within ¼ of 1% and completely automatic operation . . . assures uniform blend . . . reduces blending costs by 50%.

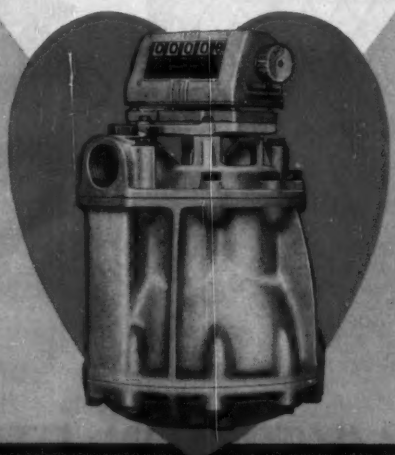


BOWSER METERS AND ACCESSORIES . . . offer complete systems for every type of liquid control requirement

MODEL L . . . straight-reading dial records liquid metered up to 100,000 gallons.

IMPULSE TRANSMITTER . . . transmits electrical impulses to a remote counter which records quantities, controls automatic batching.

MODEL K . . . Printing Dial provides printed records of quantities metered for inventory control, etc.



MODEL F . . . relays voltage signal to a remote flow indicator or controller permitting remote observation and control of the flow rate.

MODEL RP . . . automatically delivers repeated predetermined quantities of liquids.

REMOTE PREDETERMINING COUNTER . . . records electrical impulses from meter permitting automatic delivery and shutoff control for predetermined quantities.

XACTO METER . . . the HEART of Bowser liquid handling systems

Mail to BOWSER, Inc.

1329 E. Creighton Ave., Fort Wayne, Indiana

Please send complete information illustrating the many types of Bowser systems available.

NAME_____

TITLE_____

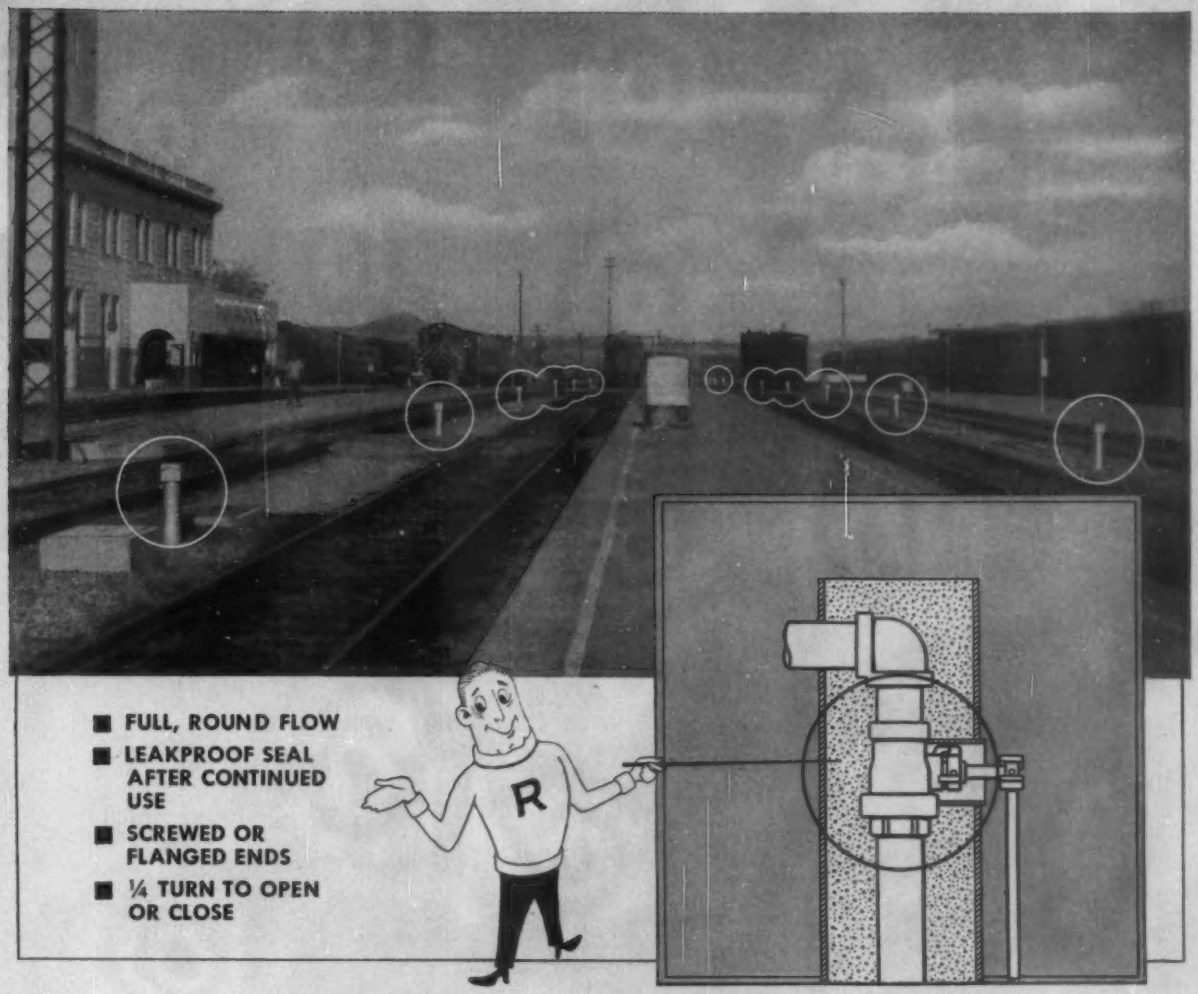
COMPANY_____

STREET_____

CITY_____ STATE_____

XACTO . . . meters assure precision accuracy. Available in bronze, iron and all stainless steel construction.

Bowser's full line of meters, accessories and controls combine to offer you today's most automatic, economical and modern liquid handling systems.



Rockwood Ball Valve

Positive Shut Off – Positively Leakproof

Rockwood's forged Ball Valves solve tough water handling problem at Southern railroad station. A quarter turn opens and closes this valve without leakage — even after continued use! The liquid pressure automatically positions ball against the synthetic rubber seat — and the retainer spring assures tight seal in case the pressure is very low. It's trouble-free, long wearing and job designed. Several seat materials available for different applications. The coupon will bring full information on how you can reduce maintenance costs by using Rockwood Ball Valves. Tested and listed by Underwriters' Laboratories, Inc. Distributors in all principal industrial areas.

ROCKWOOD BALL VALVES

ROCKWOOD

ROCKWOOD SPRINKLER COMPANY
2232 Harlow Street
Worcester 5, Mass.

Please send me illustrated folder on Rockwood Ball Valves.

Name.....

Title.....

Company.....

Street.....

City.....Zone....State.....

For more data on advertised products, use Readers' Service Cards, last page.

Photo taken at Delaware Refinery, Tidewater Oil Company

They feed the big cats

Feeding the big catalytic crackers takes close coordination of refining and chemical technology. Leading refiners and Cyanamid chemists worked together to pioneer the development of synthetic cracking catalysts, the first fully regenerative platinum reforming catalyst, the first high alumina catalyst.

Behind Cyanamid's service as a major catalyst producer are its unlimited resources as a major chemical producer.

Cyanamid's man with the golden rule can bring further progress through unique catalytic and chemical research and development facilities.

Basic in Catalyst Chemistry

CYANAMID

AMERICAN CYANAMID COMPANY • REFINERY CHEMICALS DEPARTMENT • 30 Rockefeller Plaza, New York 20, N. Y.

Originators of AEROCAT® Fluid Cracking Catalysts, AEROCAT TRIPLE A® High Alumina Catalysts, AEROFORM® Fluid Hydroforming and Platinum Reforming Catalysts, AERO® Specialty Catalysts, CYPAN® Drilling Mud Conditioner, AEROLUBE® Lubricating Oil Additives, AERONOX® Antioxidants, AEROSOL® Surface Active Agents

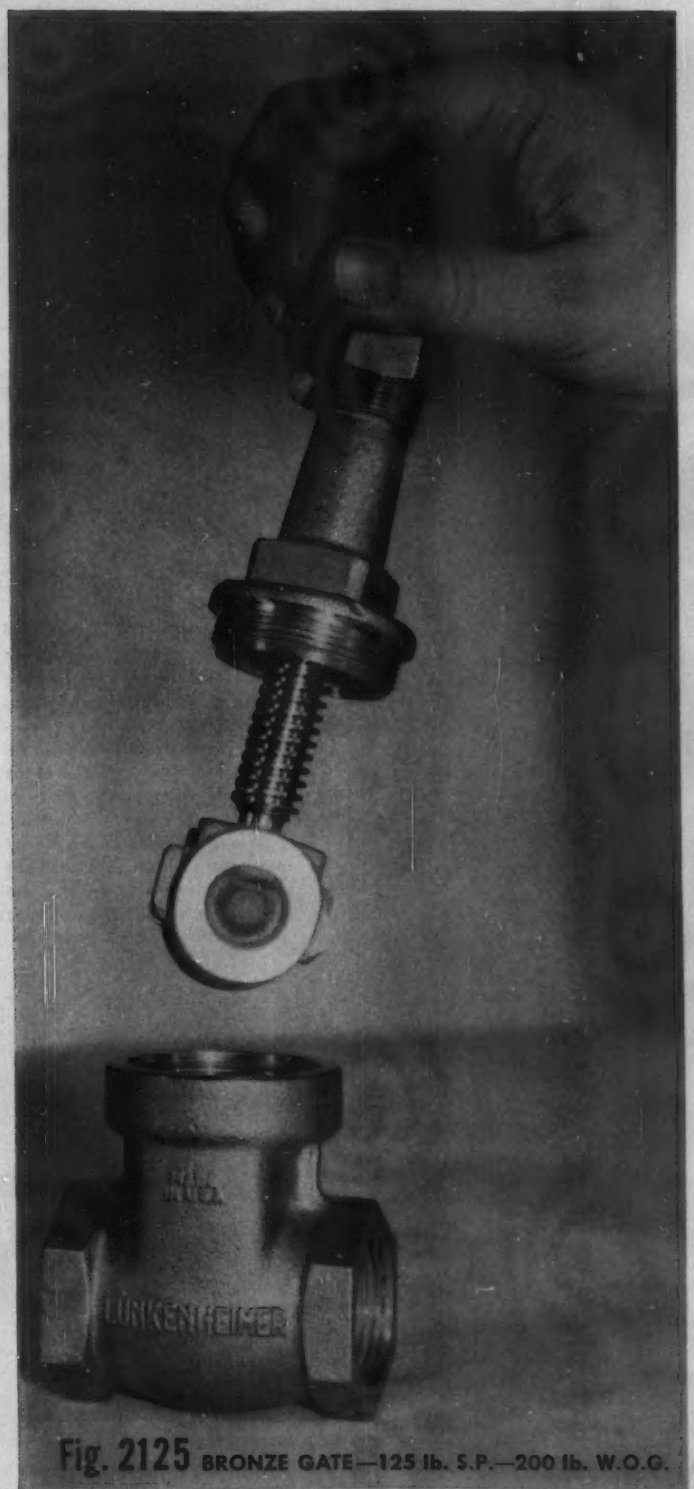


Fig. 2125 BRONZE GATE—125 lb. S.P.—200 lb. W.O.G.

SEE WHY LUNKENHEIMER BRONZE GATE VALVES CUT MAINTENANCE

What you pay to maintain a valve can exceed its original cost many times over. That's why it pays to examine the maintenance-saving features of Lunkenheimer Bronze Gate Valves.

Stems are made of Stemalloy®, an exclusive Lunkenheimer alloy that assures longer stem thread life. Integral seats are precision tapered to insure perfect seating. Discs are compounded for long, wear-resistant service, machined to a high finish for smooth, trouble-free operation.

Let your Lunkenheimer Distributor show you the maintenance-saving features of Lunkenheimer Bronze Gate Valves and why you can't find the cost of a valve on a price list... Or write The Lunkenheimer Co., Cincinnati 14, Ohio.

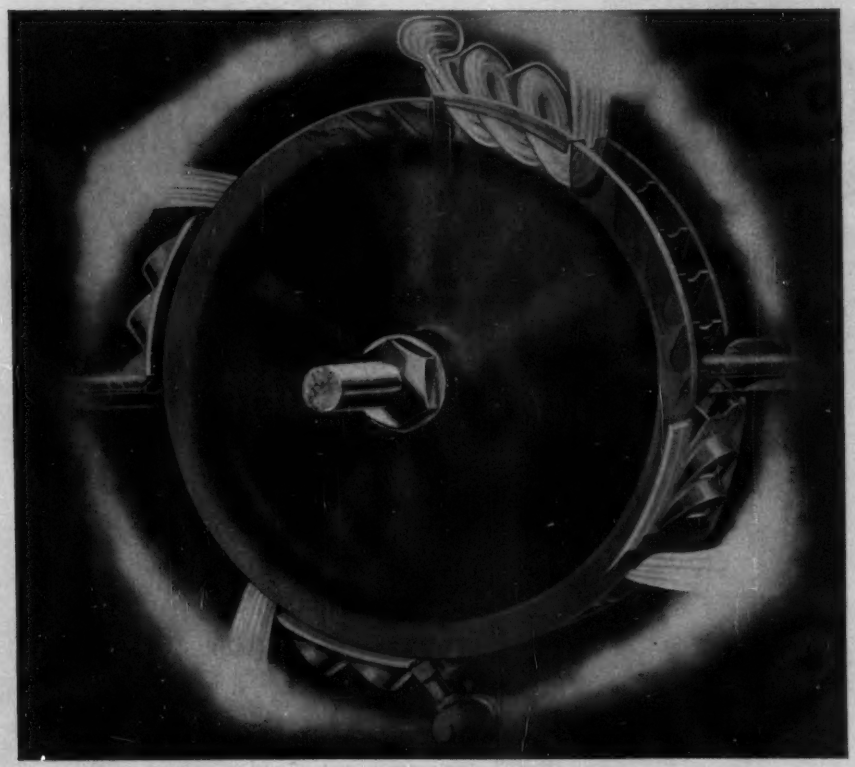
LUNKENHEIMER QUALITY

LUNKENHEIMER®

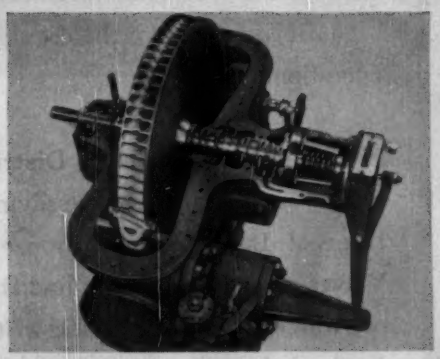
THE ONE *Great* NAME IN VALVES

For more data on advertised products, use Readers' Service Cards, last page.

TURBINE BLADES CAN'T FOUL!



The Terry solid-wheel turbine is of the impulse, helical flow type. The steam issues from an expanding nozzle at high velocity and enters the wheel bucket where its direction is reversed 180°. As this single reversal uses but a portion of the available energy, the steam is returned to the wheel several times until practically all of the energy has been utilized. This principle makes possible the efficient use of steam in a single-piece, almost indestructible wheel.



Terry solid-wheel design permits large clearances

In the Terry solid-wheel turbine, the steam enters the buckets in a direction at right angles to the shaft, as shown above. This design eliminates the need for close clearances and provides positive blade protection.

The blades cannot foul. There is a one inch clearance on either side of the wheel. In addition, projecting rims on each side of the buckets prevent damage to the blades even though external thrust should move the wheel.

This is only one of the many advantages of Terry solid-wheel turbines. Write for complete details. Ask for a copy of bulletin S-116.

TERRY

THE TERRY STEAM TURBINE CO.
TERRY SQUARE, HARTFORD 1, CONN.

TT-1206

For more data on advertised products, use Readers' Service Cards, last page.

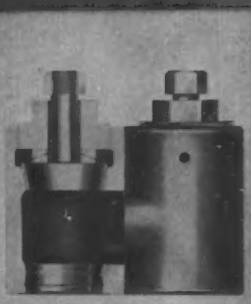
Ohio FITTINGS and RETURN BENDS

Photo shows operator spraying return bend in preparation for Magnaglo inspection.

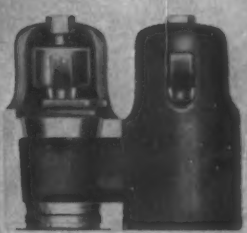
Magnaglo production surface inspection

Ohio Steel is the first steel foundry to install this special Magnaglo unit for quick and accurate surface inspection of Cast Return Bends and Fittings for the oil and chemical industries.

We invite you to witness this operation and see our other modern foundry and machining facilities.



Type 1500



Type 1000

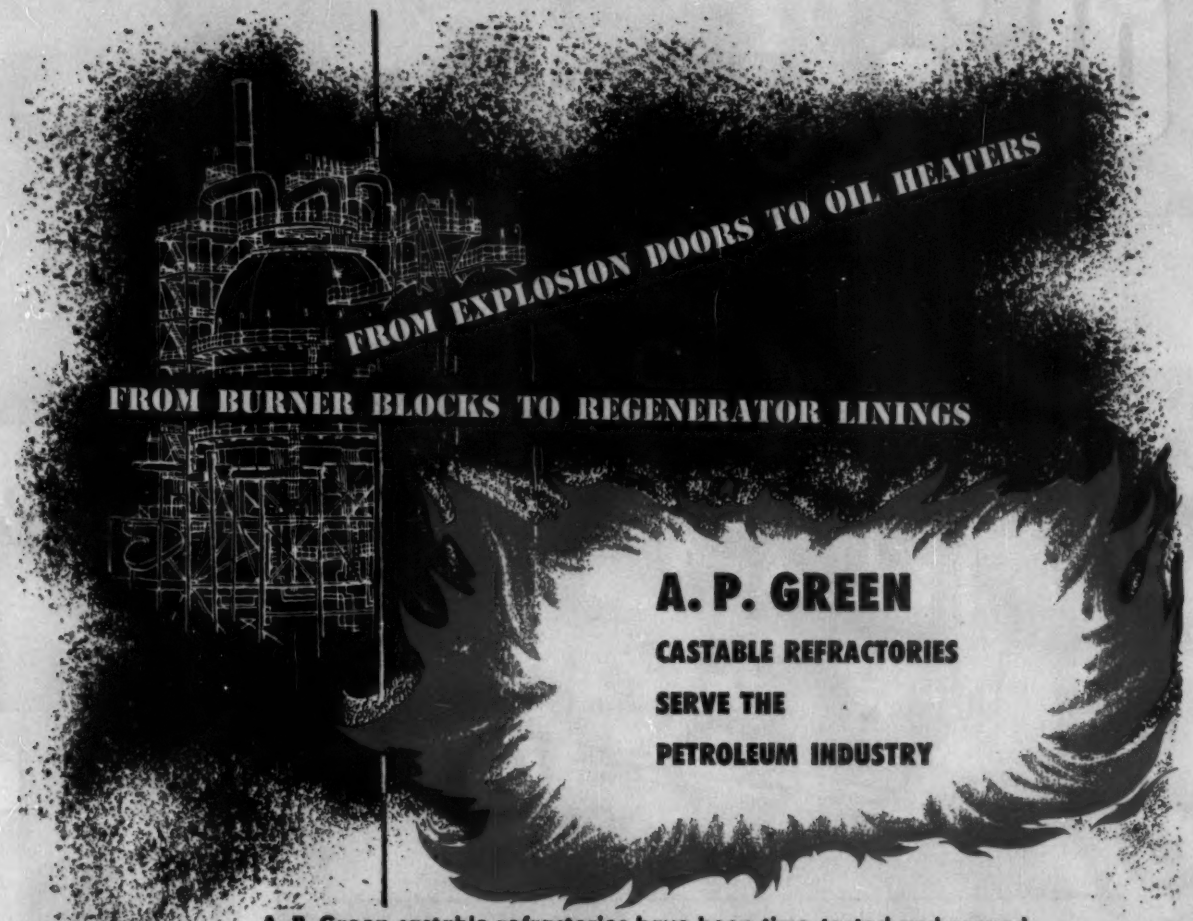
Type 1001-W2

1907 50 YEARS 1957

THE OHIO STEEL FOUNDRY CO.

SPRINGFIELD, OHIO

Plants at Springfield and Lima, Ohio



A. P. Green castable refractories have been time-tested and proved in the field... for every specific refractory application in the petroleum industry. *Results achieved:* reduced "down time" and labor costs... lower fuel costs and increased heating efficiency... greater safety and reduced maintenance control.

For detailed information and specific recommendations... write, Engineering Department, A. P. Green Fire Brick Company... or call your local A. P. Green distributor.

A. P. Green Castable Refractories... designed to exact specifications to do an exact job

KAST-SET — A rapid setting, high strength refractory castable. Mixed with water, it takes on a hydraulic bond without the application of heat. KAST-SET will not shrink, has excellent resistance to abrasion, and is ideally suited for monolithic linings. It may be used at temperatures up to 2700° F.

KAST-O-LITE — A lightweight castable recommended for temperatures up to 2500° F. It is used for monolithic linings in all types of stills and heaters, tar stills, heat treating furnaces, flues, and stacks. Reduces heat loss. Insures closer temperature distribution and control.

CASTABLE INSULATION NO. 20 — A hydraulic-setting castable for temperatures up to 2000° F. Recommended for complete monolithic linings and lightweight panel construction in oil stills and heaters. Weighs 50 pounds per cubic foot in place.

CASTABLE BLOCK MIX — A hydraulic-setting castable insulation for temperatures up to 1600° F. CASTABLE BLOCK MIX combines the advantages of a castable material with low conductivity and light weight. It provides maximum insulating efficiency and ease of installation. Weighs only 20 pounds per cubic foot in place.

CASTABLES FOR GUN APPLICATION... SK-7 — Gun application of SK-7 produces a lightweight lining with excellent strength and insulating efficiency for temperatures up to 1800° F. Installation and labor costs are reduced... no forms required. Ideal lining for ducts, flues and breechings.

KS-4 — This strong abrasion resistant castable can be gun applied with a minimum of rebound loss. Recommended for catalytic regenerator linings, stack linings, bubble towers, and duct linings exposed to abrasion or corrosion. For temperatures up to 2550° F.

A. P. Green REFRACTORY PRODUCTS

A. P. GREEN FIRE BRICK COMPANY

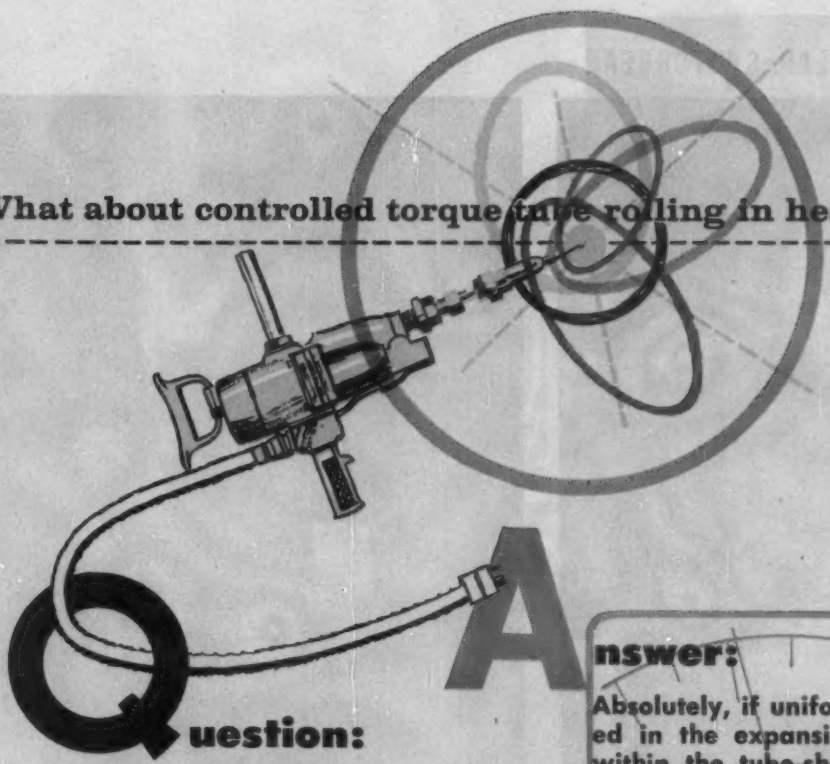
Mexico, Missouri, U.S.A.

Plants: Mexico, Mo. — Woodbridge, N. J. — Sulphur Springs, Texas — Jackson, Oak Hill, South Webster, Ohio — Philadelphia, Pa. — Troy, Idaho

IN CANADA: **A. P. GREEN FIRE BRICK COMPANY, LTD.**
Toronto 15, Ontario

DISTRIBUTORS IN THE PRINCIPAL CITIES OF THE WORLD

What about controlled torque tube rolling in heat exchangers?



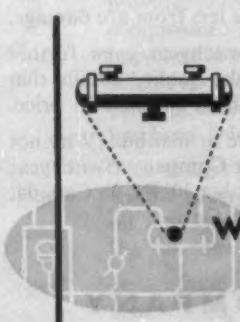
Question:

Is controlled torque tube rolling *imperative* to high quality heat exchanger fabrication?

Answer:

Absolutely, if uniformity is expected in the expansion of the tube within the tube-sheet. The highly specialized electronic equipment used assures a fluid-tight joint, and protects . . .

. . . Western customers against human error. With the application of the controlled torque principle, the entire tube rolling operation becomes a matter of mechanical precision and machine perfection. As a result, Western heat exchangers are structurally sounder, are less susceptible to corrosion and can be retubed more easily. Controlled torque tube rolling at Western eliminates the dangers of over-rolling and work-hardening, which so often cause structural weakness, invite corrosion, and increase maintenance costs.



WESTERN
HEAT EXCHANGERS

WESTERN SUPPLY COMPANY
P.O. Box 1888 – Tulsa, Oklahoma

Constant attention to the potentials and restrictions of a wide range of metals is reflected in Western's application of controlled torque tube rolling for *all* customers.

For more data on advertised products, use Readers' Service Cards, last page.

METAL-CLAD SWITCHGEAR

TORCHES IGNITE FLAMETRAP (bottom) and conventional insulation (top) simultaneously.

SECONDS LATER, FLAMETRAP has snuffed out, but conventional insulation still burns briskly.

New FLAMETRAP Insulation Snuffs Out Flame ...No Toxic Gases...Highest Arc Resistance

FLAMETRAP INTERPHASE BARRIER. Standard equipment on I-T-E 5 and 15 kv switchgear at no increase in price.

Take the heat away, and this new I-T-E developed FLAMETRAP insulation snuffs out . . . fast! This is today's most advanced flame-retardant insulation, and it is used exclusively in I-T-E Switchgear.

FLAMETRAP contains melamine resin—heretofore considered too expensive for commercial application. Unlike substitute ingredients, melamine gives off no toxic gases when it burns. So FLAMETRAP is far safer. And melamine stands up better under high temperatures. So FLAMETRAP suffers less from arc damage.

This latest improvement puts I-T-E switchgear even further ahead of the pack. It is one more of the quality details that keep coming your way from I-T-E without increase in price.

I-T-E service is as near as your telephone or mailbox. Why not call or write today. I-T-E Circuit Breaker Company, Switchgear Division, 19th & Hamilton Sts., Philadelphia 30, Pa. In Canada, Eastern Power Devices Ltd., Port Credit, Ont.

I-T-E CIRCUIT BREAKER COMPANY
PHILADELPHIA, PENNSYLVANIA

Clark Centrifugals...

PROVED DESIGN

gives higher compression ratios with built-in alignment at conservative speeds

Clark centrifugal compressor design with bearing supports cast integral with the case provides permanent alignment for the life of the compressor. This permits the use of up to 10 impellers in a single case without compromising safety. As a result, you get higher compression ratios at conservative speeds. This performance has been field-proved at every installation.

This design provides sufficient area to permit the use of any seal including the Clark pressure oil film type seal between the gas stream and the bearings.

In addition to a complete line of multi-stage centrifugals, Clark also builds a gas turbine to drive many of them. Design and performance of every Clark machine stems from Clark's encyclopedia of experience. Call your nearest Clark representative for all the facts. Or write today for Bulletin 150 to Clark Bros. Co., 1302 Lincoln Avenue, Olean, New York.

CLARK BROS. CO.

One of the Dresser Industries

Sales and service outlets in principal cities throughout the world

CLARK®

CENTRIFUGAL COMPRESSORS • GAS TURBINES

For more data on advertised products, use Readers' Service Cards, last page.

most lube oil additives start with WESTVACO® BARIUM!

Westvaco long has been the leading supplier of barium chemicals used in more than three-fourths of all detergent and dispersant lube oil additives! We worked closely with additive researchers in developing readily soluble barium values suited to their needs. And to keep abreast of the growing demand, we have steadily increased our productive capacity and mineral reserves.

For any barium chemical need, whether for lube oils or other uses, Westvaco should be your first source of supply. Our nearest office will be glad to discuss your requirements.

Putting Ideas to Work

FOOD MACHINERY AND CHEMICAL CORPORATION
Westvaco Mineral Products Division

General Sales Offices:
161 E. 42nd STREET, NEW YORK 17

For more data on advertised products, use Readers' Service Cards, last page.

FOR YOUR
PIPE FABRICATION
NEEDS...

FREE

16-page illustrated brochure shows Flori-Houston fabrication team, illustrates the equipment and processes used, and provides several interesting case histories of outstanding fabrication jobs. Write today for your free copy.

FLORI-HOUSTON

gives you

ALL THREE OF THE BIG THREE

The Right
PRICE

Here's why *your* cost for fabricated piping is lowest from Flori-Houston: By processing thousands of tons of piping per year, Flori-Houston's two huge plants offer you low shop costs, made possible only through mass production techniques.

Permanent shop craftsmen, instead of transient field workers, utilize the latest automatic equipment to further minimize your fabrication costs. With Flori-Houston, you can be sure the price is *right*.

Finest
QUALITY

A full-time piping metallurgist, using the physical and chemical facilities of the research and development laboratory, is an important factor in Flori-Houston's leadership in the expanding field of critical alloy piping.

Quality control is rigidly maintained at Flori-Houston by an inspection team responsible only to management, working with X-ray, magnaflux, dye check and other scientific techniques. Accurate dimensions are insured by close inspection of each piece before shipment, as shown in illustration (at left) of the checking floor.

Dependable
DELIVERY

Flori-Houston has unique delivery advantages because shipments can be made economically to most destinations from either of the two plants. Resulting flexibility virtually eliminates the delivery problems inherent in the normal single plant operation.

Massive Houston Plant, shown at left, with 560 x 106 feet of unrestricted floor area, gives idea of comprehensive Flori-Houston facilities.

GENERAL OFFICES

THE FLORI PIPE CO.

601 East Red Bud St. Louis 15, Mo.

HOUSTON OFFICE

HOUSTON PIPE & STEEL, Inc.

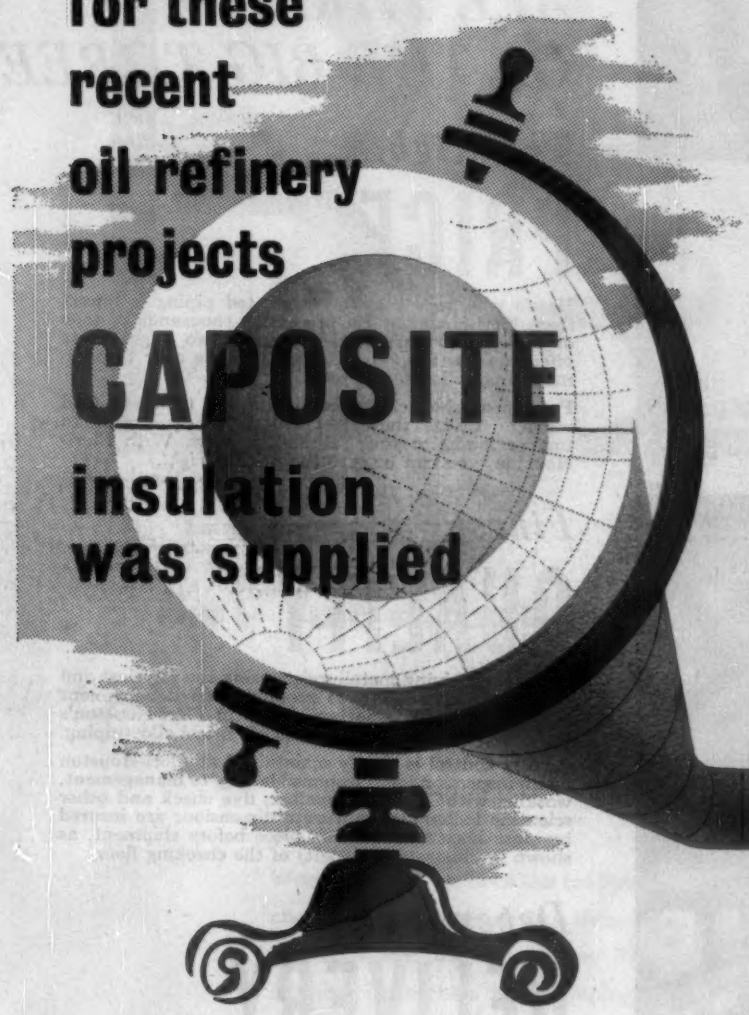
P. O. Box 2, Houston 1, Texas

Divisions of Sparton Corporation

For more data on advertised products, use Readers' Service Cards, last page.

for these recent oil refinery projects

CAPOSITE insulation was supplied



BAHRAIN *at Awali*
for Bahrain Petroleum Co. Ltd.
Main Contractor: Foster Wheeler Ltd.

BURMA *at Syriam*
for The Burma Oil Co. (1954) Ltd.
Main Contractor: Foster Wheeler Ltd. (London)

CANADA *at Clarkson, Ontario*
for British American Oil Co. Ltd.
Main Contractor: The Lummus Co.

COLOMBIA *at Cartagena*
for International Petroleum Co. Ltd.
Main Contractor: Bechtel Corporation
(Insulation Contractor: Harold Aber & Co.)

ECUADOR *at La Libertad*
for the Anglo-Ecuadorian Oil Co. Ltd.
Main Contractor: Procon (G.B.) Ltd.

ENGLAND *at Kent Oil Refinery*
for The British Petroleum Co. Ltd.

FRANCE *at Raffinerie de Normandie*
for Compagnie Francais de Raffinage.
Main Contractors: Kellogg International Corporation and Foster Wheeler Ltd. (France).
(Insulation Contractor: Soc: Technisol).

IRAQ *at Daura, near Baghdad*
for Iraq Government Oil Refinery Administration.
Main Contractor: Foster Wheeler Ltd. (London).

ITALY *at Genoa*
for Raffineria Dottore E. Garrone.
Main Contractor: C.T.I.P.

KUWAIT *at Akmadi*
for the Kuwait Oil Co. Ltd.
Main Contractors: Bechtel-Wimpey and E. B. Badger & Sons Ltd.

THE NETHERLANDS *at Pernis*
for N. V. de Bataafsche Petroleum Maatschappij.

NETHERLANDS ANTILLES
at C.P.I.M. Refinery, Curacao
for Royal Dutch-Shell Group.

SCOTLAND *at Grangemouth*
for British Hydrocarbon Chemical Co. Ltd.
Main Contractor: E. B. Badger & Sons Ltd.

VENEZUELA *at Maracaibo*
for The Richmond Exploration Co.
Main Contractor: The Lummus Co.

CAPOSITE *regd.*

Amosite Asbestos Blocks and Pipe Sections

Speedy application .... long-lasting protection .... resilience to withstand rough handling .... long fibred Amosite asbestos, giving superior insulating properties — these are the reasons why CAPOSITE is being specified for more and more of today's refineries.

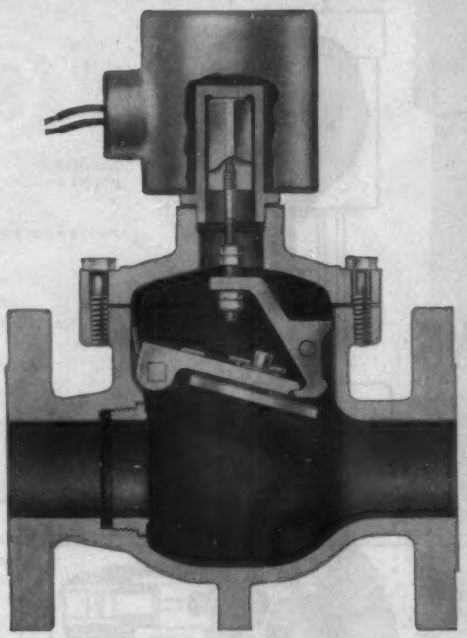
CAPOSITE *is also manufactured in* SOUTH AFRICA, ITALY, CANADA, FRANCE, HOLLAND, SPAIN

THE CAPE ASBESTOS COMPANY LTD
114 & 116 PARK STREET, LONDON, W.1
Tel: GROsvenor 6022 Cables: Incorrupt London

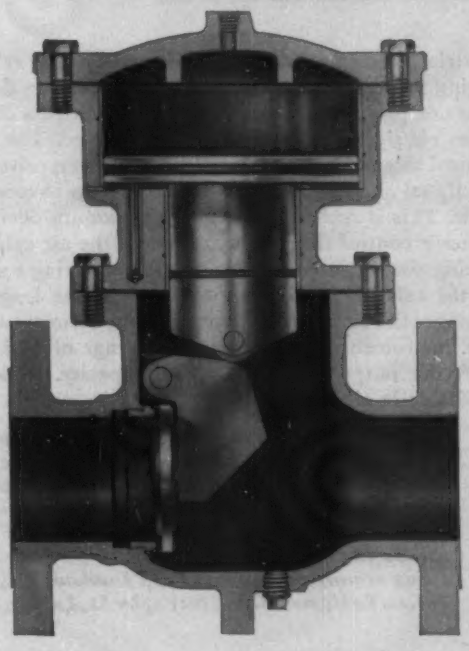
Enquiries in Canada to:
Cape Asbestos (Canada) Ltd., 200 Bloor Street East, Toronto, Ont.
U.S.A. to: North American Asbestos Corpn., Board of Trade Building, Chicago, 4, Illinois

TA 415

Latch type valve closes instantly



Piston type valve opens instantly



Coppus Sentry® Valves Give Split-Second Action

Coppus Sentry Valves automatically protect property, materials, and processing with their quick, positive action. These are all full-flow valves for use on liquid and gas lines.

The latch-type valves stop flow instantly, automatically. They may be actuated by excess flow, overpressure, underpressure, overtemperature; or by energizing or de-energizing a solenoid.

These valves remain closed until manually reset. They are extremely popular in the chemical, petroleum and gas industry.

The piston type valve opens instantly. Opening and closing of this valve may be from any remote location — either automatically or manually. It is ideal for deluge systems.

Sizes run from $1\frac{1}{2}$" to 8".

To get a more detailed story on this remarkable line of Coppus Sentry Valves, use the coupon to ask for Bulletin 500. Coppus Engineering Corp., Worcester 2, Mass.

ANOTHER COPPUS "BLUE RIBBON" PRODUCT

COPPUS ENGINEERING CORPORATION
418 Park Avenue, Worcester 2, Mass.

Please send Bulletin 500

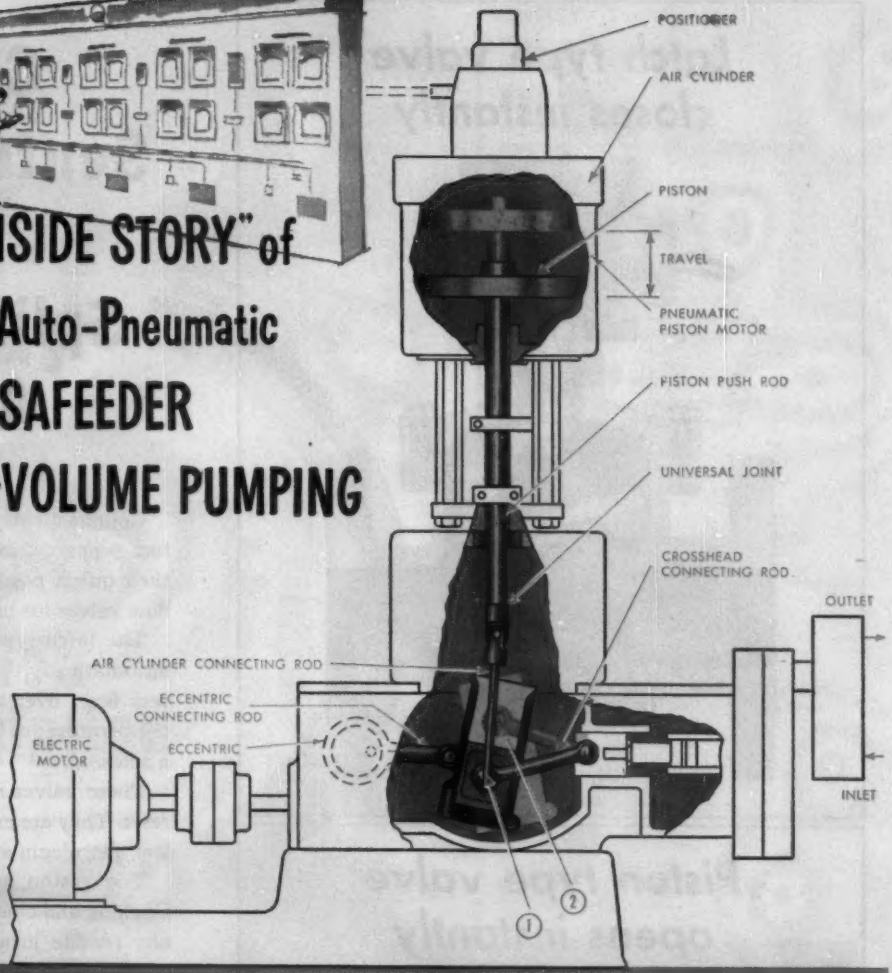
Name.....

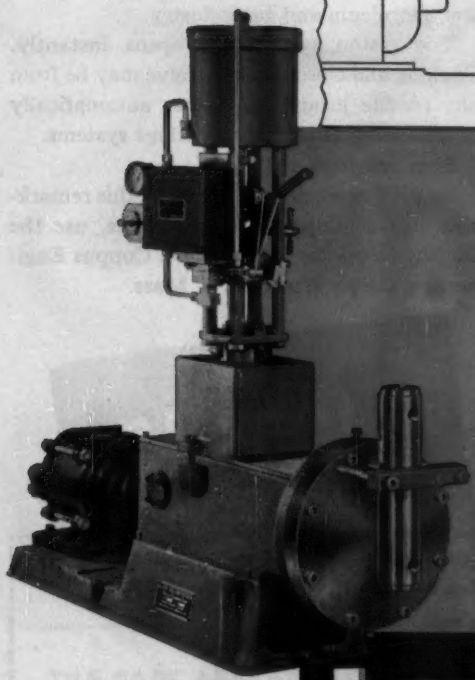
Company .....

Address.....

For more data on advertised products, use Readers' Service Cards, last page.

The "INSIDE STORY" of Auto-Pneumatic PULSAFEEDER CONTROLLED-VOLUME PUMPING





In many industrial processes, liquids must be metered in relation to some changing process condition. It can be a change in flow or pH, temperature or pressure. Instruments can sense such a change and transmit an air signal descriptive of that change. The auto-pneumatic control mounted on the Pulsafeeder pump receives and interprets this signal and automatically adjusts pump to meet the process variable. This is accomplished by a positioning device on the auto-pneumatic control that loads or unloads the air cylinder, accurately moving the air piston to position the connecting rod (1) in relation to the axis (2). This determines the stroke length of the pump—a longer stroke increases pump output; a shorter stroke reduces output. Instrument air pressure over a range of 3-15 psig. controls Pulsafeeder output from 0-100% of capacity. Ratio adjustment is available in all models.

WRITE FOR BULLETIN 440 *with typical applications, flow charts, description and specifications of both* MANUALLY CONTROLLED *and* AUTO-PNEUMATIC *models of various capacities and constructions. Inquiry Data Sheet included from which we can make specific engineering recommendation for your processing requirement. Write Lapp Insulator Co., Inc., Process Equipment Div., 3401 Poplar St., Le Roy, N. Y.*

Lapp

Complete control
of temperatures with
PABCO
PRECISION-MOLDED
CALTEMP
a Calcium Silicate
Insulation

Name your temperature. A performance-proved Pabco pipe or block insulation will maintain it at economical levels up to 1900° F. With Pabco Caltemp, 85% Magnesia, or Prasco Insulations, heat losses are reduced to an absolute minimum . . . finest performance assured. For data on technical advantages, case histories, or engineering consultation . . . write . . . or contact one of Pabco's insulation engineers.

PABCO INDUSTRIAL INSULATIONS DIVISION

Fibreboard Paper Products Corporation • San Francisco 19 • Chicago 54 • Houston 4 • New York 16 • Los Angeles

For more data on advertised products, use Readers' Service Cards, last page.

rigid specifications

Tension tests are required to be made at room temperatures and at 670° F. The following minimum physical properties shall be met:

At Room Temperature:

TS	YS	EL	RA	CHARPY V-NOTCH
70,000	30,000	45	50	50

At 670° F. the minimum tensile strength shall be 51,000 p.s.i. and the minimum yield strength 18,300 p.s.i.

Rejection

Each casting that develops unacceptable defects during shop working or fails to conform to all of the requirements of these specifications shall be rejected. No repair by welding or other means will be permitted.

Radiographic Inspection

(a) Paragraph S5 (a) of the Supplementary requirements of ASTM-A 362-52T.

(b) All castings shall be radiographed 100% and shall conform to ASTM-E7 1-52, Class 2 quality, except as modified by these specifications.

(c) The manufacturer shall establish a positive system of identification of the X-ray plates which shall be subject to approval by the inspector. This system shall guarantee complete coverage by radiographing and provide for positive identification between the plate and the subject.

Inspection of Penetrants

All castings shall be subjected to inspection by fluorescent penetrants or penetrating dyes both inside and out. All cracks, porosity, or flaws revealed as a result of the Dye Penetrant Test shall be due cause for rejection of the casting.

All cast pipe shall be hydrostatically tested to 5,900 p.s.i. and held at that pressure for 20 minutes with zero pipe leakage. Each length of pipe shall be hydrostatically tested at the manufacturer's plant.

The 304L stainless steel shall conform to the following ladle analysis:

Carbon	.03 max.		
Manganese	1.50% max.		
Phosphorous	.03% max.		
Sulphur	.03% max.		
Silicon	2.00% max.		
Chromium	18.00	-	21.00%
Nickel	8.00	-	11.00%

Pipe: All pipe of the following sizes shall be centrifugally cast stainless steel as per ASTM-A 362-52T, except as modified by these specifications:

16" - Sch. #160
12" - Sch. #160
10" - Sch. #160
8" - Sch. #140

All pipe shall be machine finished to 125 micro-inch interior and exterior.

for nuclear piping met by U.S. PIPE metal mold process

Centrifugally Cast Stainless Steel Solves Many Piping Problems

Combinations of temperatures, pressures and corrosive conditions never encountered before: these are among the piping problems that must be overcome by the men who design the nation's nuclear power installations.

Stainless steel centrifugally cast pipe provides many of the answers. Study the specifications at the left . . . specifications demanded of stainless steel pipe on a recent job for Paul Hardeman, Inc., Los Angeles, California. This pipe is being used for heavy duty, high pressure, elevated temperature service in the primary piping system of the SPERT-III Reactor at the U. S. Atomic Energy Commission's National Reactor Testing Station near Idaho Falls, Idaho. The Stearns-Roger Mfg. Company, Denver, Colorado, is the architect-engineer on this project. A complete tabulation of the actual test data obtained on this pipe and to this specification is available upon request.

U. S. Pipe is headquarters for metal mold centrifugally cast alloy and stainless steel pressure pipe over a wide range of special and standard analyses—in large and small quantities—and to individual specifications.

If piping of the type described above is the bottleneck in your nuclear power planning, write and outline the problem.

Outside Diameter—6" to 50"

Wall Thickness—⅜" and up

Length—Up to 16'

Types of Stainless—All Standard AISI and ACI grades of ferritic and austenitic stainless, including No. 20 Alloy, 17-4 P H, 17-7 P H and E.L.C. grades.

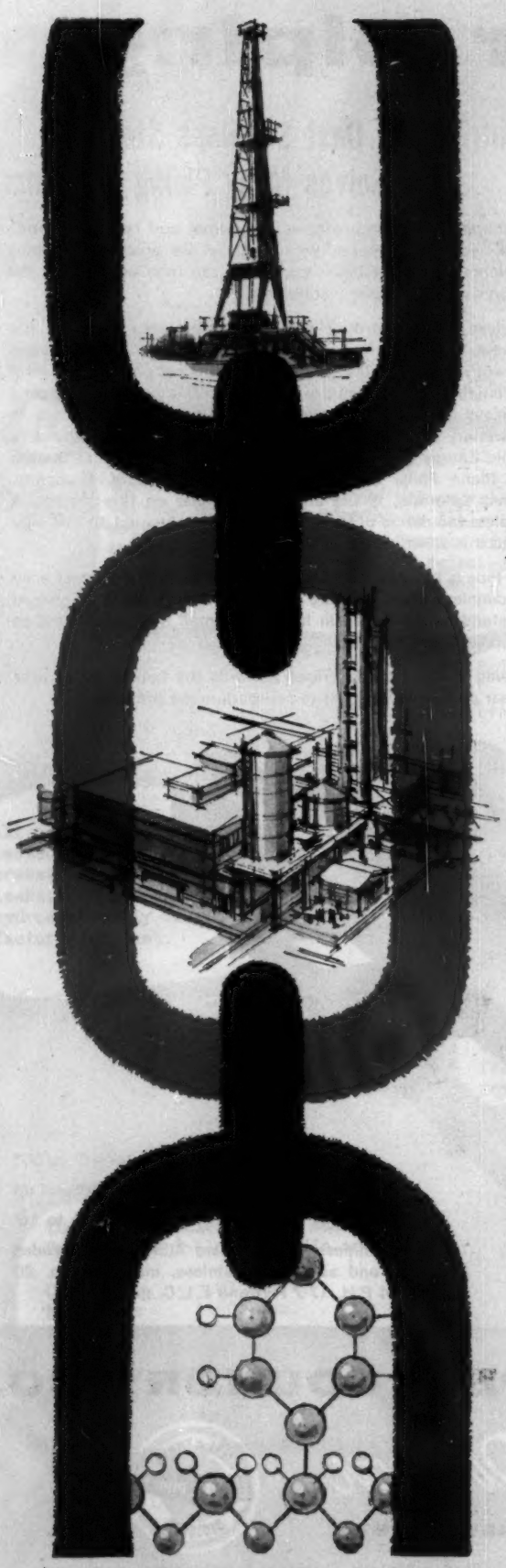
UNITED STATES PIPE & FOUNDRY CO.

Steel and Tubes Division

BURLINGTON, NEW JERSEY

STEEL & TUBES U.S. PIPE DIVISION

SALES OFFICES: LOS ANGELES, SAN FRANCISCO, CHICAGO, ST. LOUIS, COLUMBUS, PITTSBURGH, HARTFORD, BURLINGTON



Blaw-Knox supplies vital link in Cosden's crude-to-plastic chain

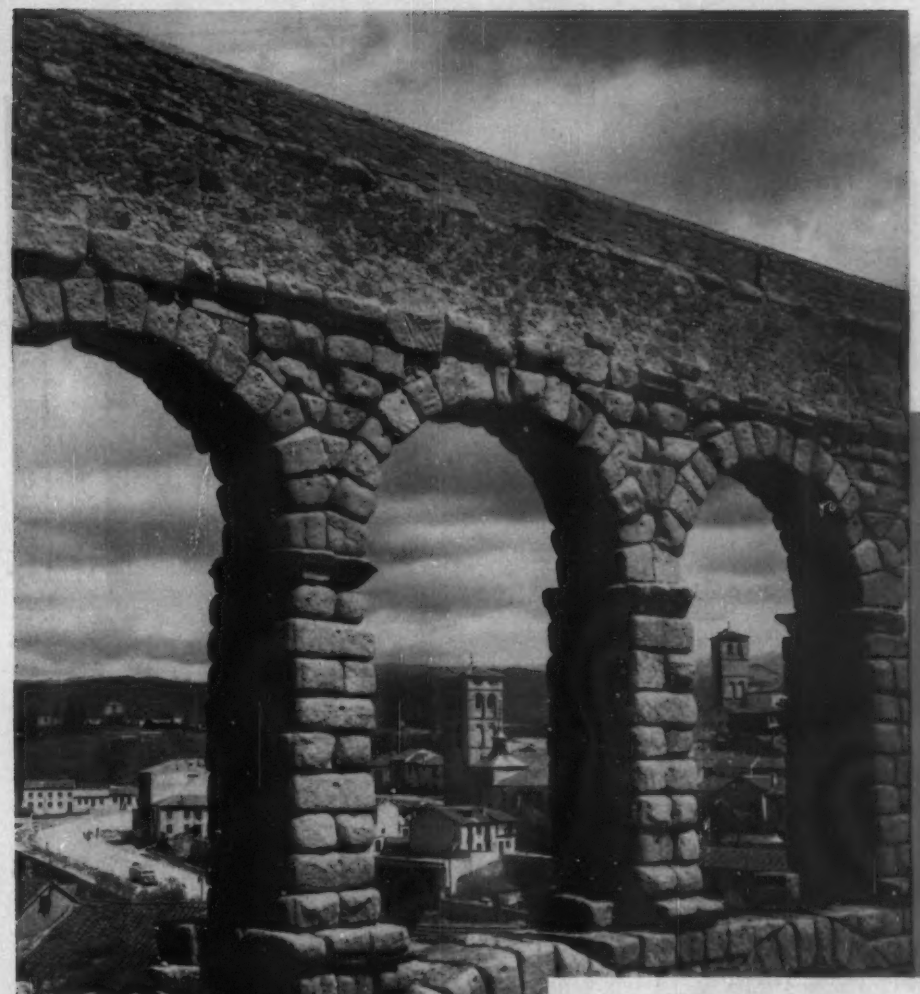
From crude oil to ethylbenzene to styrene and finally polystyrene—with this pace setting program, Cosden Petroleum Corporation makes oil industry history. In designing and building Cosden's polystyrene plant, Blaw-Knox proudly joins this enterprising company in the vanguard of petrochemical activity.

A unique combination of know-how in resin manufacturing, chemical production and petroleum refining has made Blaw-Knox a leading contractor for industry's most progressive projects.

Perhaps this background of over 90 plastic and resins facilities can be helpful to you. Contact our engineering staff for a conference. Blaw-Knox Company, Chemical Plants Division with production offices in Pittsburgh and Chicago. Branch offices in Birmingham, New York, Haddon Heights, New Jersey, San Francisco and Washington, D.C.

for plants of distinction . . .

BLAW-KNOX



This Roman aqueduct at Segovia, Spain, built 1900 years ago to carry water from a mountain stream, is still in use. Called today "El Puente del Diablo", the bridge part is 847 yards long.

Roman specialists in water conveyance surely built their aqueducts to last. Though current designs for critical piping in power and processing plants may in time become obsolete, you want your next high-pressure, high-temperature job to be permanently safe and enduring. That calls for dealing directly with experienced specialists. So, ask us in.

W. K. MITCHELL & CO., INC.

Philadelphia 46, Pa.

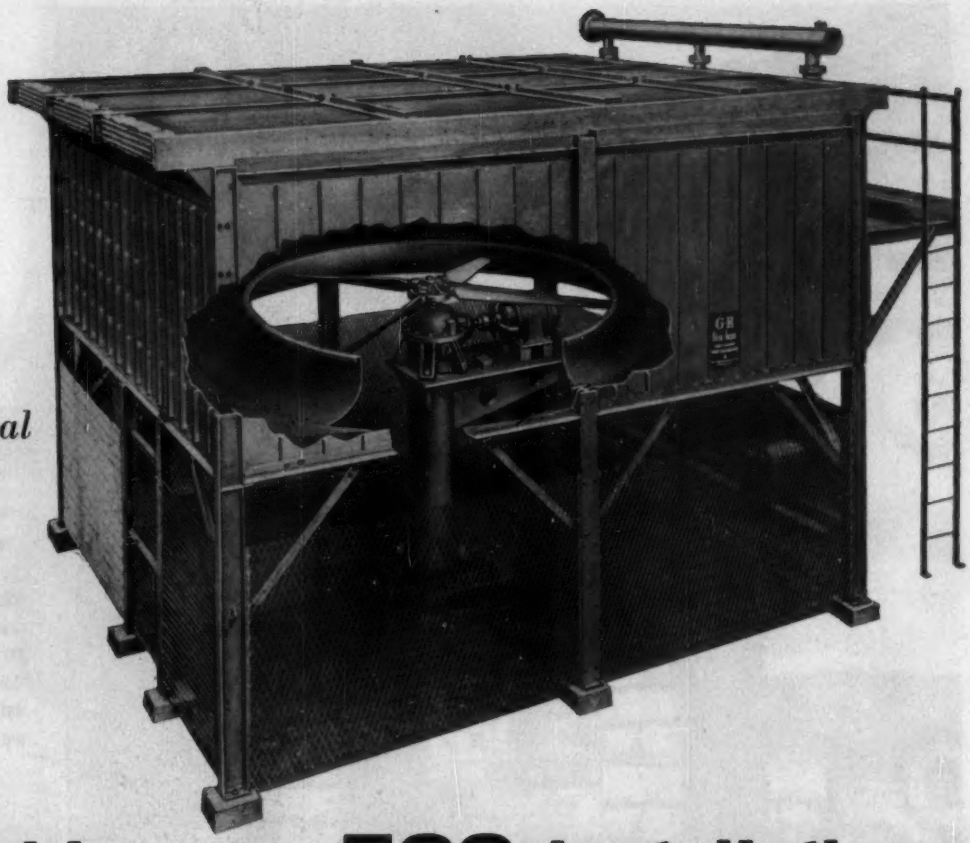
WESTPORT JOINT
(PATENTED)

MITCHELL PIPING
SINCE 1899

PIPING FABRICATORS AND CONTRACTORS

For more data on advertised products, use Readers' Service Cards, last page.

Designed for the Petrochemical Industry



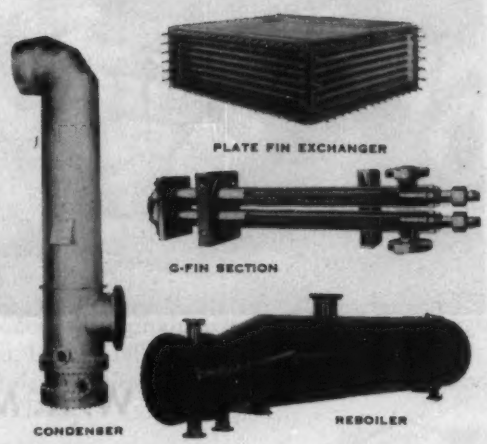
Proved in over 500 installations

Griscom-Russell fin-fans, by eliminating the cost of water, pumps, piping, valves, water treatment and maintenance, are the economical heat exchangers for many petrochemical cooling and condensing services.

G-R **fin-fans** are designed of the highest quality components to fit your special application. The transfer area is made of G-R's strong, helically finned tubing for highest efficiencies. Exceptional design and pre-fabricated construction minimize installation and maintenance expenses.

fin-fans are available in forced or induced draft designs with a wide range of capacities. Many accessories are available to solve special drive, control and weather problems.

Send for Griscom-Russell Bulletin 2400.



G-R Designed for the Petrochemical Field

Reboilers • G-Fin Sections • Condensers • Plate Fin Exchangers • Longitudinally and Helically Finned Tubing • Bentube Evaporators • Liquid Heaters • Tubular Heat Exchangers • Solution Heaters • Oil and Water Coolers • Tank Heaters • Gas Coolers • Bentube Sections

HEAT EXCHANGE EQUIPMENT FOR THE PETROCHEMICAL INDUSTRY

GR 350

Griscom-Russell

GENERAL PRECISION EQUIPMENT CORPORATION

THE GRISCOM-RUSSELL COMPANY • MASSILLON, OHIO
A SUBSIDIARY OF GENERAL PRECISION EQUIPMENT CORPORATION

For more data on advertised products, use Readers' Service Cards, last page.

CARBON COPIES

OF TWO MAJOR DEVELOPMENTS

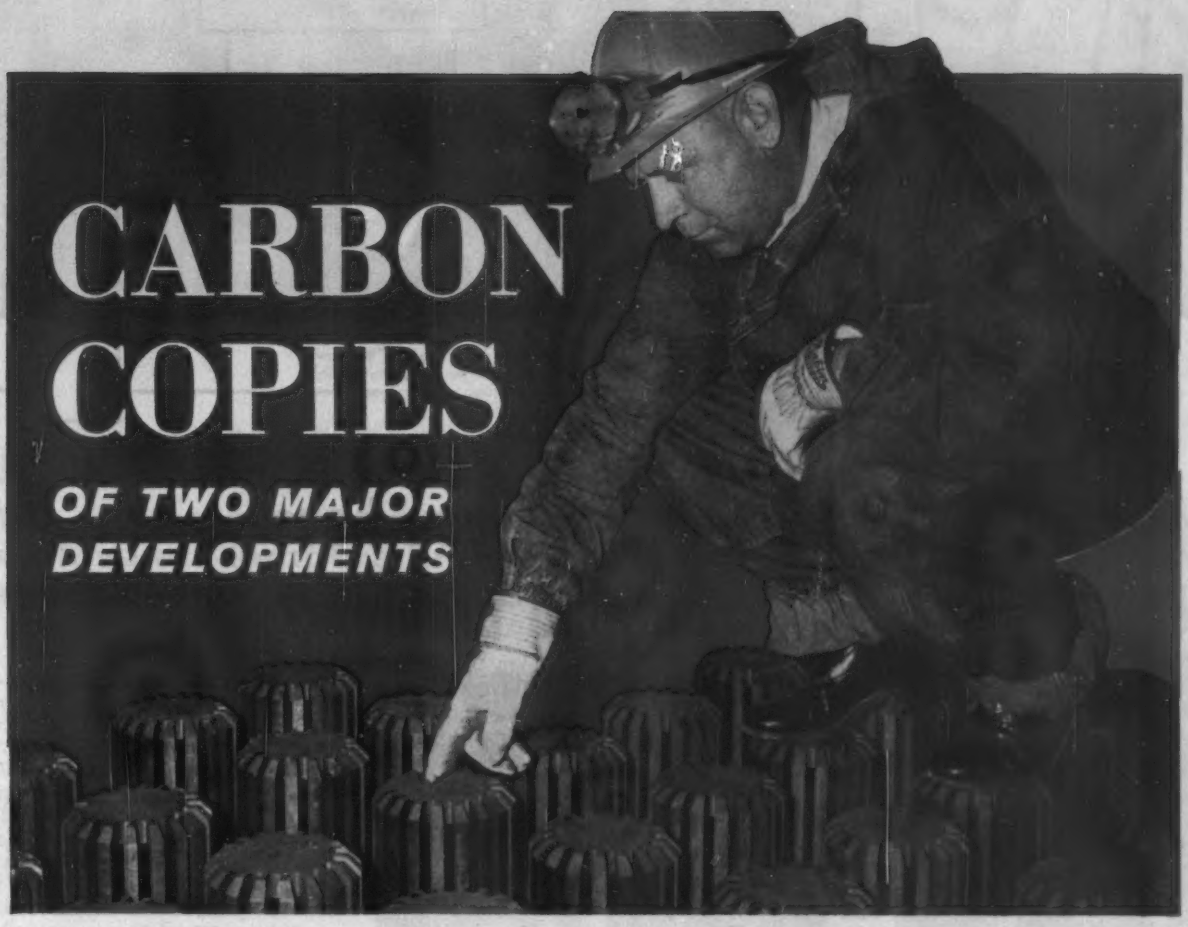
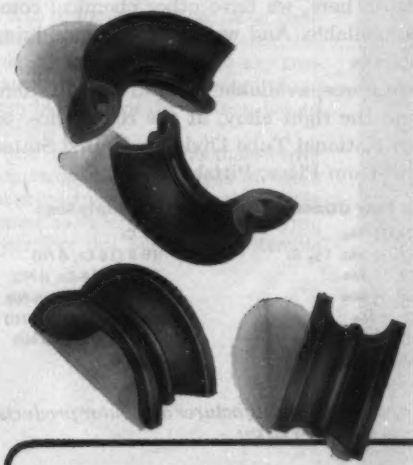


Photo Courtesy Bakelite Company



Where packed columns were to operate at elevated temperatures (above 250°F-300°F) or with corrosives which attack ceramics, the engineer has been decidedly limited in his choice of tower packings and tower support plates.

Now, as a result of the joint efforts of The U. S. Stoneware Co. and the National Carbon Co., Intalox Saddle packing and "Gas-Injection Weir-type" Support plates are available in carbon—to function in that portion of the spectrum where metals and ceramics are unsatisfactory.

Because both the Intalox saddles and the Weir-type Support plates are all carbon—with no extractable binder—such diverse corrosives as alkalies, sulphuric, hydrochloric, phosphoric, hydrofluoric acids and hot dichlorbenzene offer no problem.

Now, in carbon, are all the advantages that characterize Ceramic Intalox Saddles: low pressure drop, high flooding limits, higher mass transfer coefficients, lower HTU. Now, in carbon, is a packing support plate that provides negligible pressure drop since it provides better than 50% free space under actual operating conditions. These newer developments are just two more reasons why chemical engineers with problems in packed tower design, say—"Consult U. S. Stoneware first."

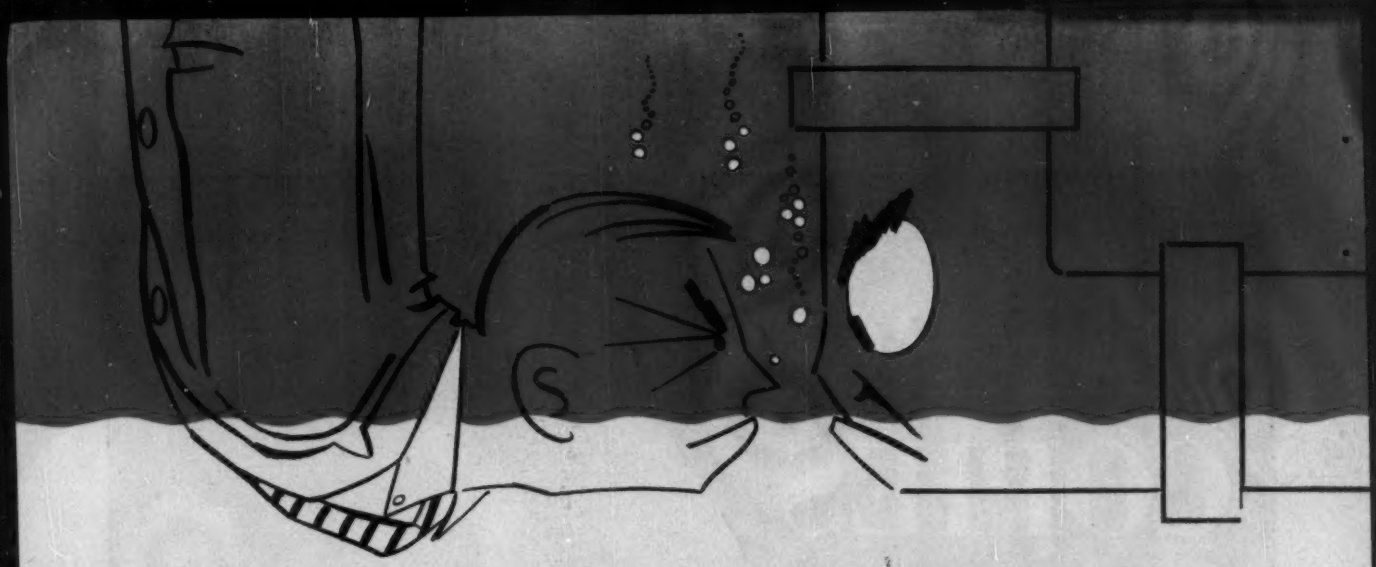
Do You Have These Engineering Bulletins?

Bulletins S-29, TP-54 and TA-30 contain helpful data on tower packings, tower support plates and distributors. Free on request.

167-F

U. S. STONEWARE

AKRON 9, OHIO



You say you have an acid problem?

If your refinery acid problems are so bad that they're creating acid problems in your stomach, maybe you'd better get in touch with National* Tube. We can't give you medical advice, but we can sure straighten out your refinery tubing problems. You see, we *specialize* in finding ways to combat acids, corrosion, high temperatures, high pressures, and oxidation.

Our experience in this field comes from over 60 years of collecting data on the solving of tough refinery tubing problems. We've used this data to develop 24 different steel tube analyses—each one the answer to a specific set of refinery conditions. These analyses have been proved over and over again in actual service.

Besides the 24 analyses shown here, we have other chemical compositions in tubular products available. And we're presently studying a variety of temperature problems.

National Tube's Mill Service Force, available for field consultation, will be happy to help you find the right alloy, at the right price, to meet your needs. Just write to National Tube Division, United States Steel Corporation, 525 William Penn Place, Pittsburgh 30, Pa.

Here are National Tube's two dozen different tube analyses:

Carbon	5 Cr, ½ Mo	17 Cr
Carbon, ½ Mo	5 Cr, ½ Mo, 1½ Si	18-8 (18 Cr, 8 Ni)
1 Cr, ½ Mo	7 Cr, ½ Mo	18-8 Ti (18 Cr, 8 Ni)
1¼ Cr, ½ Mo	8 Cr, ½ Mo	18-8 Cb (18 Cr, 8 Ni)
2 Cr, ½ Mo	8 Cr, 1 Mo	18-8 Mo (18 Cr, 8 Ni)
2¼ Cr, 1 Mo	9 Cr, 1 Mo	25-20 (25 Cr, 20 Ni)
2½ Cr, ½ Mo, ¾ Si	12 Cr	3½ Ni
3 Cr, 1 Mo	12 Cr, Al	5 Ni

"The world's largest and most experienced manufacturer of tubular products
NATIONAL TUBE"

National Tube Division of USS® United States Steel

®TRADEMARK

Columbia-Geneva Steel Division, San Francisco, Pacific Coast Distributors · United States Steel Supply Division
United States Steel Export Company, New York

Two-way solenoid valve mounted on sample inlet side, admits fresh air to detector unit only when air-purge button on control cabinet is depressed.

USING HIGH FLASH POINT SOLVENTS?

M-S-A® Remote Head Analyzers sample combustible vapors in elevated temperature areas such as coating ovens and drying ovens. And they do it reliably, accurately, and safely.

Combustible vapors in high temperature operations are often impossible to analyze at normal room temperature. The problem is: how to measure the sample without cooling and condensing the combustible vapors.

The M-S-A Remote Head solves this problem. Filament units are enclosed in an explosion-proof housing suitable for installation in Class 1, Group D hazardous areas. This unit may be placed in the oven or a high temperature area. This permits analysis at process temperatures without condensation of the vapors to be measured. Then, after passing through the filament chamber, the sample is allowed to cool and any condensate is trapped and disposed of, to prevent blockage of the vacuum line to the sample pump.

Where temperatures fluctuate—over a wide range in certain types of ovens—it is necessary to maintain a reasonably constant sample temperature during analysis. For this purpose, the Remote Head can be supplied with built-in, thermostatically controlled heaters to maintain a constant operating temperature within the Remote Head Assembly. This assures utmost reliability and accuracy under these sampling conditions.

An MSA Instrument Specialist would be happy to answer your specific questions on gas analysis equipment. Get in touch with him, soon. And write us for helpful new literature on the *M-S-A Remote Head Analyzer.*

INSTRUMENT DIVISION

Mine Safety Appliances Company

Pittsburgh 8, Pennsylvania

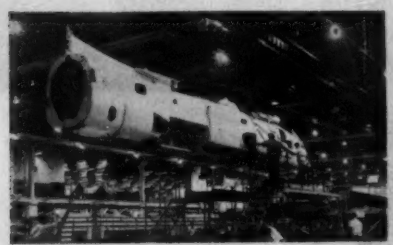
With top speed a secret, the U. S. Navy's Chance Vought F8U-1 Crusader was the first aircraft to span the continent faster than the speed of sound. Now flying with Fleet squadrons on both the Atlantic and Pacific coasts, the F8U-1 operates in a new speed range far beyond the supersonic. President Eisenhower, aboard the Saratoga when one of the epic transcontinental flights landed, observed: "You almost got here before you left."

In the photo above, Tuffy Slings are being used in hoisting the plane. 18,829 lbs. of valuable aircraft are entrusted to the quality, strength and dependability of Tuffy Slings. We think it's a fine testimonial to the kind of slings and wire rope you get when you use Tuffy.

Tuffy Slings give you more sling efficiency and longer life because Tuffy's patented machine-braided fabric is the perfectly balanced combination of strength and flexibility. Their flexibility is such as to resist kinking. When kinks do occur, they are easily straightened without material damage. And the exclusive Tuffy pressed-on ferrule makes the eye-splice as strong as the fabric. For every sling need and any sling problem, get in touch with your Tuffy distributor.

Write today for your copy of
FREE TUFFY SLING HANDBOOK
Full sling data and specifications plus complete rigger's handbook.

union Wire Rope corporation
SUBSIDIARY UNITED STATES STEEL CORPORATION
2284 Manchester Ave. **Kansas City 26, Missouri**
Specialists in high carbon wire, wire rope, braided wire fabric, stress relieved wire and strand.



Tuffy Slings play a vital part in both production and operation of the Navy's F8U-1. Here the fuselage is suspended on a Tuffy sling assembly as it moves on the production line.

Tuffy is in the act again as the F8U-1 is set to catapult. Union Wire Rope also manufactures catapult slings used on U. S. Navy aircraft carriers.

The F8U-1, landing on carrier deck, is about to catch arresting cables such as Union Wire Rope Corporation also makes for the Navy. The plane in this operation weighs more than 12 tons!

HIGH CAPACITY PACKAGED STEAM GENERATORS

by Foster Wheeler

Series AG-200 extends economy and dependability of FW Packaged Design to over 60,000 lb/hr

To meet the needs of industrial plants for high-capacity Packaged Steam Generators, Foster Wheeler offers units for capacities of 50,000 to 63,000 lb/hr and higher, depending on operating conditions.

A modification of the proven AG-100 design which has provided industry with reliable, economical steam in the range of 10,000 to 50,000 lb/hr, these compact, space-saving units permit more steam capacity in less space than has heretofore been possible. For complete details, write to *Foster Wheeler Corporation, 666 Fifth Avenue, New York 19, N. Y.*

FEATURES:

- Final Steam Temperatures to 840 F
- Design Pressures to 900 psig
- Standard Heat Recovery Arrangements Available
- 42-inch Steam Drum
- Two Burners
- Automatic Controls
- Suitable For Indoor or Outdoor Installation
- Tangent Bare Tube Furnace Side Walls and Roof
- Staggered Boiler Bank Tube Arrangement
- Fully Drainable and Removable Superheater.

THE FOLLOWING AG-200 UNITS ARE NOW IN PRODUCTION:

Capacity lb/hr	Operating Pressure psig	Final Steam Temperature Deg. F	Feedwater Temperature Deg. F	Fuel	Efficiency	Steam Quality
52,500	400	750	200	No. 6 Oil	85.5	3 ppm Solids Carryover
60,000	285	Sat.	220	Nat. Gas	78.3	3 ppm Solids Carryover
63,700	150	Sat.	225	No. 6 Oil	83.7	0.5% Moisture Carryover
68,000	620	Sat.	350	No. 6 Oil	80.9	1 ppm Solids Carryover

FOSTER WHEELER

NEW YORK • LONDON • PARIS • ST. CATHARINES, ONT.

For more data on advertised products, use Readers' Service Cards, last page.

survey of 94 installations reveals multiple benefits of

PETRECO ELECTRIC DESALTING

this is what PETRECO DESALTING can do for YOUR refinery

TOPPING UNIT BENEFITS:

1. Higher charge rates
2. Longer runs
3. Increased service factor
4. Less corrosion in topping unit
5. Higher temperature to tower
6. Less heat exchanger plugging
7. Less crude furnace plugging
8. Scheduled Shutdowns
9. Improved charge stocks for catalytic cracking

CRACKING UNIT BENEFITS:

1. Longer runs
2. Fewer tube replacements
3. Higher temperatures from furnace
4. Less reduced crude furnace coking
5. Scheduled Shutdowns

GENERAL BENEFITS:

1. Higher octane values on gasoline
2. Reduced ammonia consumption
3. Improved kerosine color
4. Cleaner fuel oil
5. Less ash in coke
6. Improved fractionation in tower
7. Disposal of slop oil by blending with desalter charge
8. Disposal of tank bottoms in same way
9. Emergency water trap during tank switches, insuring uniform charge to crude unit
10. On-schedule operation of refinery, more efficient use of personnel

not mere opinion . . .
but OPERATING FACTS

These listed benefits are not mere manufacturer's opinions. They are the careful tabulation of pencil-and-pad information obtained by personal interviews out in the field—with refinery operating personnel who actually work with Petreco Electric Desalters every day. Specific operating data were also gathered as substantial proof of these installation advantages.

If you'd like to see these operation facts, and find out more about the PETRECO DESALTING PROCESS, *write for illustrated bulletin.*

PETRECO

A DIVISION OF PETROLITE CORPORATION

DS-57-1

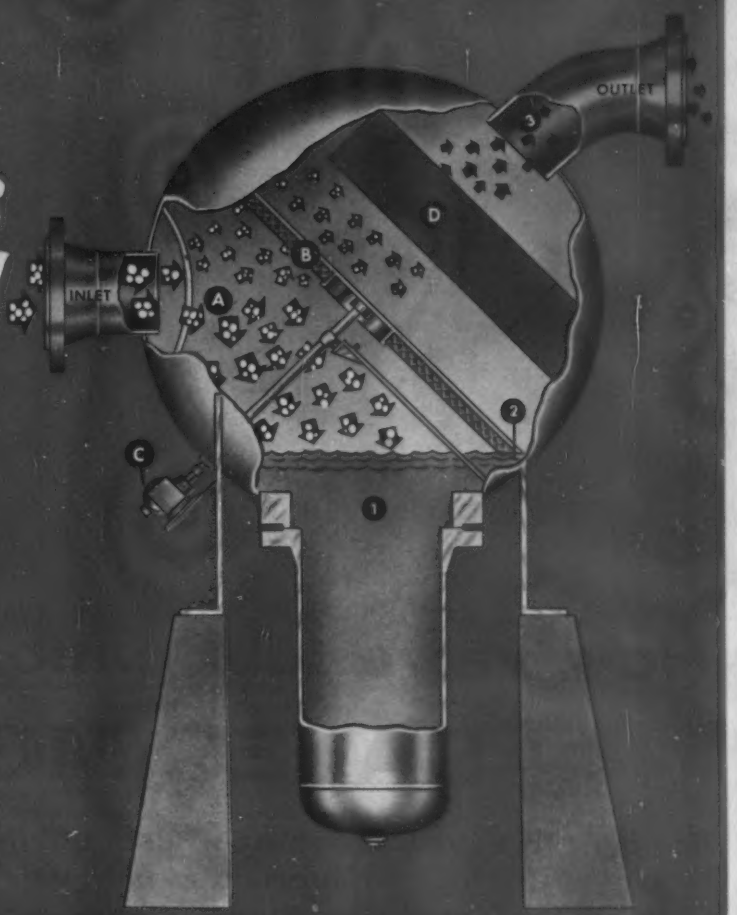
3202 S. Wayside Drive, Houston 1, Texas • 1390 East Burnett St., Long Beach 7, California

Specialized Electric Petroleum Treating

DESALTING • DEHYDRATING • CAUSTIC WASHING • ACID TREATING • DOCTOR TREATING • SWEETENING • NAPHTHENIC ACID REMOVAL • SEDIMENT REMOVAL

SCRUBOSPHERE* ...

... FOR *Cleaner Gas* AT *Less Cost!*



*PEERLESS SPHERICAL
DUST and LIQUID SCRUBBER
FOR GAS PIPELINES

LEGEND OF ABOVE CUTAWAY

The majority of incoming liquid (A) and solid particles are directed to either side and down into reservoir (1). Lighter solid particles carried by gas stream are separated on surfaces of contactor (B) which are kept wet and clean by revolving thru liquid reservoir (2). Contactor is revolved by explosion-proof gear motor (C). Mist Extractor (D) removes any remaining liquid particles from gas stream prior to outlet (3).

- The **dust removal ability** of the SCRUBOSPHERE **is superior** because it utilizes wetted surfaces for dust collection which are much more closely spaced than in conventional equipment.
- **Oil loss is minimized** because the oil used to wet the dust collecting surface is lifted mechanically instead of bubbling gas through the oil which results in foaming and loss due to creation of hard-to-separate fine particles.
- **Maximum performance and low cost** — The spherical design means high capacity and performance because it provides maximum dimensions for the contactor and mist extractor which normally are limiting factors in scrubber designs. The vessel cost is reduced because required vessel thickness is only one half that required for cylindrical vessel of same diameter.
- **Versatility** — separates solid and liquid particles with equal efficiency.
- **Low pressure drop** — ½ to ¾ psi at rated capacity depending on nozzle size.

PEERLESS MFG. CO. DALLAS TEXAS

PEERLESS MANUFACTURING CO.

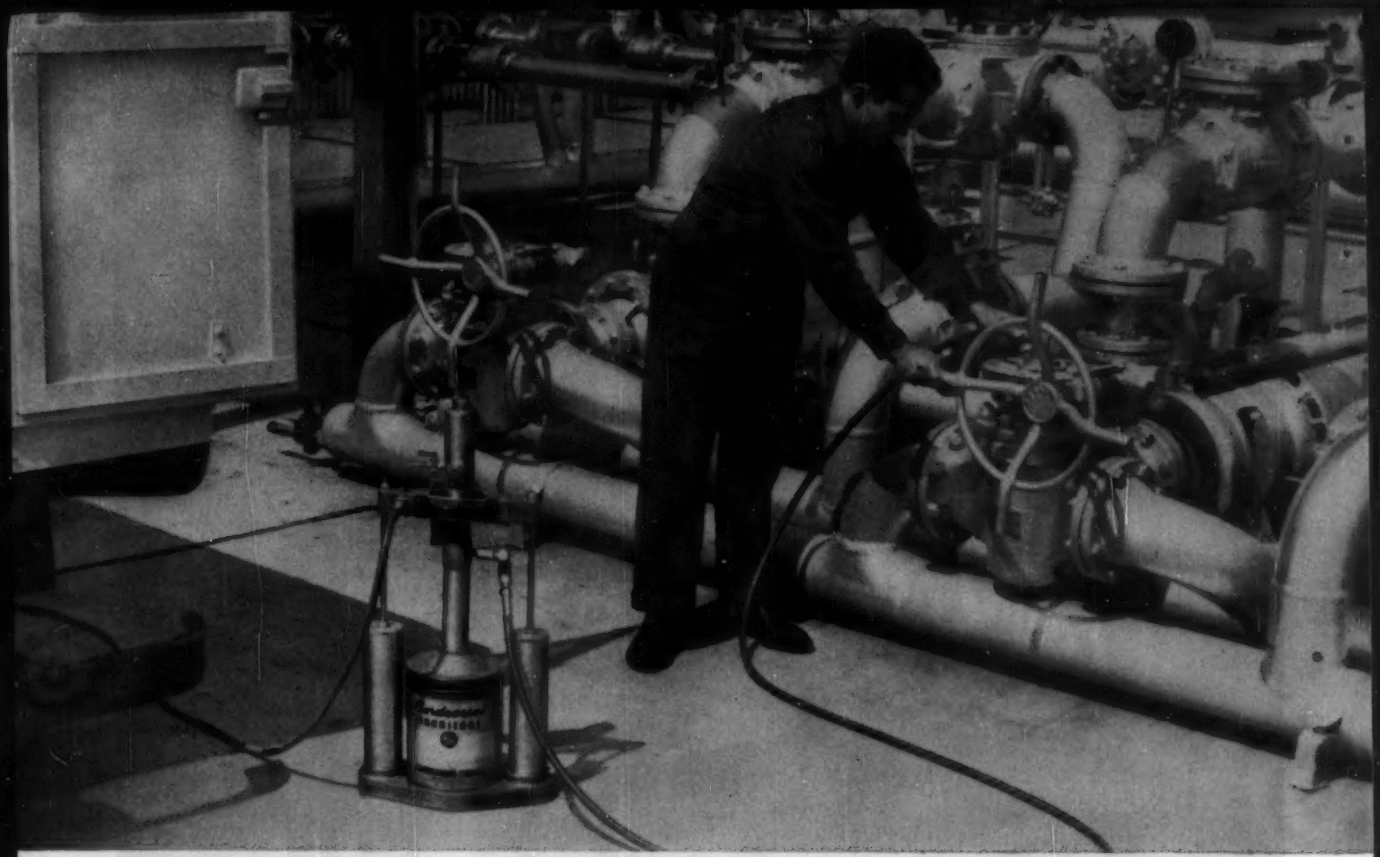
P. O. BOX 13165 DALLAS, TEXAS

Representatives in All Principal Cities

Write for test data showing dust removal and oil loss of Peerless Scrubosphere as against conventional dust scrubber.

OVER 20,000 SEPARATORS and SCRUBBERS IN SERVICE"

For more data on advertised products, use Readers' Service Cards, last page.



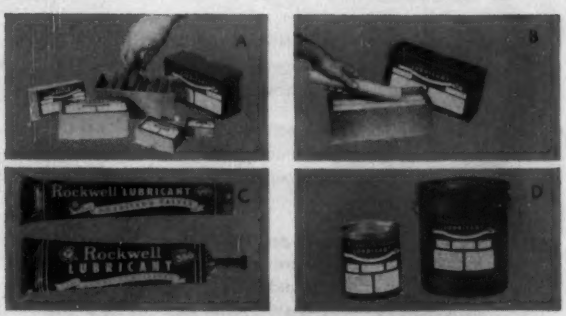
How valve lubrication SAVES MONEY

For over forty years, operation cost studies have proved that Rockwell-Nordstrom lubricated plug valves perform better, yet cost far less to use, than ordinary valves. Here's why:

THE FUNCTION OF LUBRICANT is not just to make operation easier, but to form a leakproof, positive seal between the plug and valve body. Pressurized lubricant in the Sealdport grooves is actually a kind of "soft seat" that is instantly replaceable . . . it can't be *permanently* cut, worn or scratched like metal seats. Addition of new lubricant to a Rockwell-Nordstrom valve is like reseating an ordinary valve but it costs pennies instead of dollars.

Lubricant has another *very* important job in a Rockwell-Nordstrom valve. Acting as a "hydraulic" jack the pressurized lubricant provides a means of instantly unseating and freeing the plug . . . even after years in an open or closed position.

In any mechanism with moving parts, lubrication prevents wear and reduces friction. That's why Rockwell-Nordstrom valves work easier, stay in service longer and cost less to use. The information that follows shows equipment that will help you lubricate your valves more efficiently and at lower cost.



WORLD'S MOST COMPLETE LINE OF LUBRICANTS. Rockwell is the largest and oldest manufacturer of lubricated plug valve lubricants. Each lubricant is a result of painstaking research and careful field testing. A complete list of lubricants and the services for which they are recommended is available . . . use the coupon on the facing page.

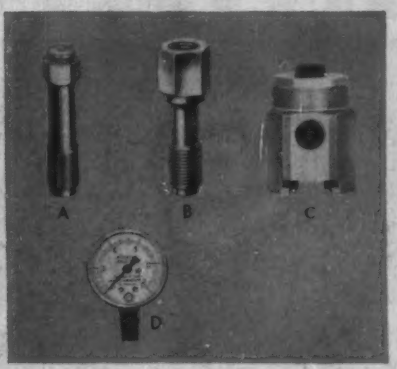
The lubricant types illustrated above are (A) Stick Lubricants for manual insertion. (B) Stick Lubricants for lubricant guns, for fast, easy lubrication through the Rockwell fitting on the valves. (C) Gun Tubes for fast refilling of lubricant guns and convenient bulk tubes (spout type) for individual valve lubrication. (D) Bulk Lubricants in five quart and five gallon pails.

HAND LUBRICATION of a few small valves is done easily by unscrewing the Rockwell fitting with any standard wrench and inserting Rockwell stick lubricant. Screwing down the fitting creates proper lubricant pressure.

ROCKWELL HIGH PRESSURE HYDRAULIC HAND GUN is used at installations similar to those recommended for the booster gun. The Hydraulic Gun develops much higher lubricant pressures with less manual effort making it suitable for lubricating larger valves.

ROCKWELL BOOSTER HAND GUN provides high pressure lubrication for small or medium sized valves at installations where a moderate number of valves are to be maintained. Quickly loaded with stick lubricants, the hand gun is fast, easy to operate and insures proper lubricant pressure within the valve.

ROCKWELL HYPREGUN saves time and labor at large valve installations especially where there are numerous large valves. The Hypregun is a compact, self-priming air operated lubricant bucket gun. Using 5 qt. pails of lubricant, it's easy to properly service the largest valve installations.



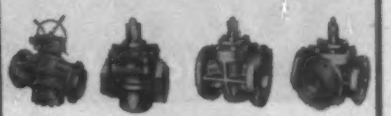
LUBRICATION ACCESSORIES. Just a few of the lubrication accessories available from Rockwell are shown above. The Rockwell Fitting (A) is now standard on all valves. The drilled and tapped lubricant screw (B) makes a convenient fitting for use with pressure gauges or gun fittings. The Rockwell 400 giant button head coupler (C) has a built-in shut-off to eliminate lubricant extrusion from residual pressure in the hose (the "400" is standard on all Rockwell guns and pumps). Pressure gauges (D) for hand guns and bucket pumps tell *automatically* when correct lubricant pressure is reached . . . also indicate when valve needs further gland adjustment.

How to Select Rockwell-Nordstrom Valve Lubricants

Complete details on the proper lubrication of Rockwell-Nordstrom valves and the proper lubricant formula number for a wide range of services are detailed in Rockwell Bulletin V-220. Generally, the following information is vital to the selection of the proper lubricant:

1. Precise description of the line material to be valved.
2. Temperature range to which valve will be subjected.
3. Pressure range within which the valve will work.
4. Size and type of Rockwell-Nordstrom valves.
5. Frequency of operation.
6. Type of lubricant (stick, gun tube, pail or bucket) to be used.

Rockwell's lubricant research staff will be pleased to give special attention to operating problems not specifically covered in the literature.



ROCKWELL-Nordstrom VALVES

it's **ROCKWELL** MANUFACTURING COMPANY

Rockwell Manufacturing Company
Pittsburgh 8, Pa.

☐ Please send me Rockwell Bulletins V-218 and V-220.

☐ Please have your sales representative call to discuss specific problems.

Name_____

Address_____

City_____ Zone_____ State_____

1 QUICK APPLICATION INSULATES, PROTECTS, FINISHES!

EAGLE-PICHER
ONE-COTE CEMENT

- Saves time, work, money! One quick application provides smooth, light reflectant surface on hot or cold equipment!
- Clean, easy to handle! Just trowel it on—even on irregular areas where application of other insulations is often impractical.
- Highly efficient! Effective insulation at temperatures up to 1000 F.
- For outdoor installations! Quick-setting, withstands rain and moisture two hours after application. Prevents rust!
- For indoor installations! Requires no wire mesh or finishing treatment!

FREE SAMPLE!
Write today!

Prove to yourself, on your equipment, how Eagle-Picher One-Cote Cement can save you time, money and valuable man-hours.

Eagle-Picher produces a complete line of industrial insulations for all temperatures from below Zero to over 2000 F.

Since 1843

EAGLE EP PICHER

EAGLE-PICHER

The Eagle-Picher Company • General Offices: Cincinnati 1, Ohio

(*Member of Industrial Mineral Fiber Institute*)

For more data on advertised products, use Readers' Service Cards, last page.

DE LAVAL
IMO PUMPS

are now more versatile than ever

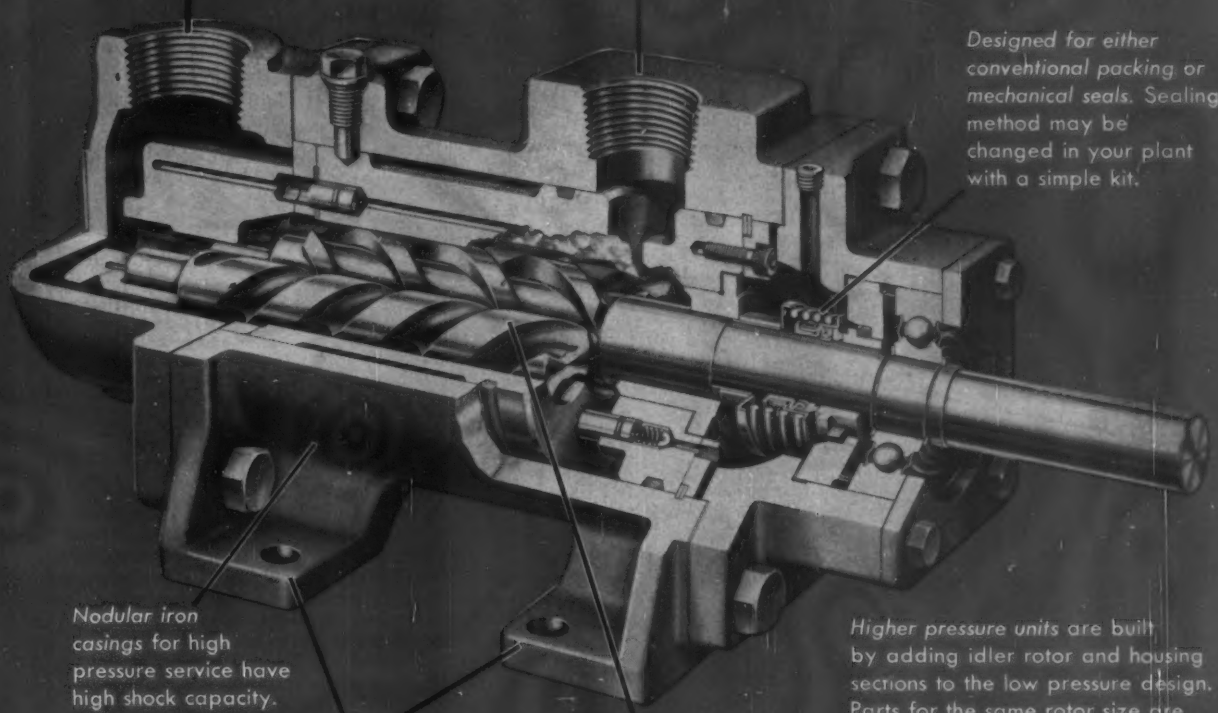
De Laval IMO pumps have proved that they do a dependable job over long years of service. The reason is IMO design simplicity. These constant displacement rotary pumps have only three moving parts—smoothly intermeshing rotors that propel the fluid axially in a steady flow without churning, pocketing or pulsation. There are no timing gears, cams, valves, sliding vanes, or reciprocating parts to wear or become noisy. *Quiet*, compact IMO pumps are excellent for direct-connected, high-speed operation.

In addition to these basic pumping advantages, the improved IMO gives you important new benefits shown in the cutaway illustration below.

DE LAVAL IMO PUMPS can also be used as hydraulic motors.

Inlet can be rotated to suit installation arrangement.

Discharge flanges are infinitely varied. You can use the most advantageous piping method to suit installation requirements.



Designed for either conventional packing or mechanical seals. Sealing method may be changed in your plant with a simple kit.

Nodular iron casings for high pressure service have high shock capacity.

Higher pressure units are built by adding idler rotor and housing sections to the low pressure design. Parts for the same rotor size are interchangeable over the entire pressure range.

Any position mounting is possible without factory modification.

Internal parts are designed as a package so that units can be built into your machines.

Bulletin 3001 gives data on improved De Laval IMO pumps. Send for your copy today.

DE LAVAL *IMO Pumps*

DE LAVAL STEAM TURBINE COMPANY

811 Nottingham Way, Trenton 2, New Jersey

DL 418

These Wagner Motors are designed to

Cut Operating Costs

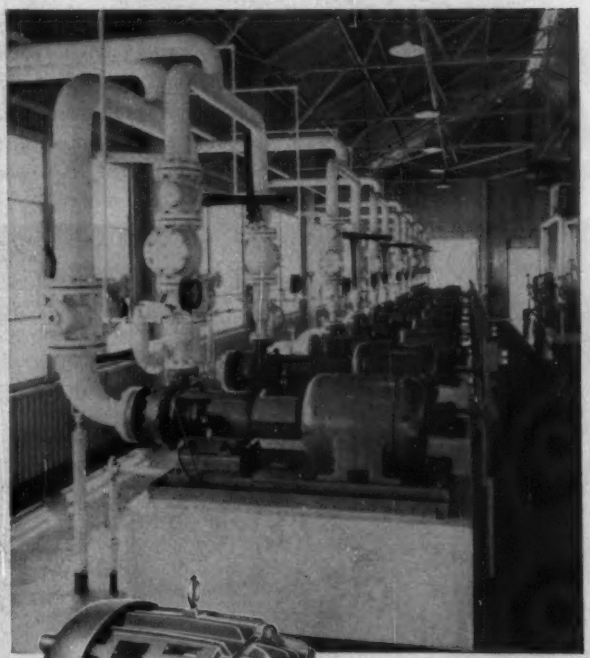
in the oil fields

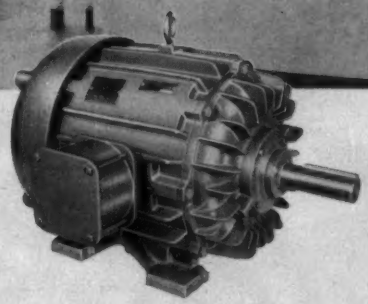
Type DP or DY oil well pumping motor. Single phase or polyphase.

Separate weatherproof control box, for use with single phase motors.

Wagner oil well pumping motors are especially designed for cost-cutting year round, maintenance-free, rugged outdoor service. They are protected against rain, sand, snow, by an enclosure that is completely drippproof—virtually splashproof. They are protected against corrosion by cast iron frames and endplates. Conduit boxes are moistureproof and dust-tight. They are available from stock in your immediate area for either polyphase or single phase operation. Single phase motors are of the high power factor capacitor start and run type with a separate weatherproof control box that contains the starting and running capacitors and voltage relay.

in the refinery





Type JP, Explosion-proof, totally-enclosed polyphase motor. Available in ratings through 250 hp.

You cut costs when you install Wagner Type JP Explosion-proof motors in your refinery because these totally-enclosed motors have extra protection that means longer motor life with little maintenance—the vital parts of the motor are sealed against the entrance of dust, fumes and moisture that are the causes of most motor maintenance problems. These motors are approved for Class 1, Group D hazardous locations, and can be used indoors or in exposed outdoor locations where corrosion is a problem. Totally enclosed fan-cooled motors are available in ratings through 400 hp.

For full information, write for Bulletins MU-132 and MU-137, or phone a nearby Wagner branch.

Wagner Electric Corporation
SERVING INDUSTRY SINCE 1891

WH58-3

BRANCHES AND DISTRIBUTORS IN ALL PRINCIPAL CITIES

Wagner Electric Corporation
6458 Plymouth Ave., St. Louis 14, Mo., U.S.A.

ELECTRIC MOTORS • TRANSFORMERS • INDUSTRIAL BRAKES • AUTOMOTIVE BRAKE SYSTEMS—AIR AND HYDRAULIC

When you need

BASIC CHEMICALS FOR PETROLEUM

look to General Chemical!

Here's why...

General Chemical is the leading supplier of a great many basic chemicals used in petroleum production and processing. Its nationwide chain of plants and warehouses, large-scale production, extensive research and technical service—all assure you of really dependable products and service. Call on us for these key chemicals:

ALKYLATION
Anhydrous Hydrofluoric Acid
Sulfuric Acid

POLYMERIZATION
Fluosulfonic Acid $HO{:}SO_2F$
Boron Trifluoride
Sulfuric Acid

SULFONATION
Sulfuric Acid
Sulfan® (Stabilized Sulfuric Anhydride)
Oleum

ISOMERIZATION
Hydrochloric (Muriatic) Acid

DETERGENTS, CLEANERS & BUILDERS
Sodium Metasilicate
Disodium Phosphate
Sodium Sulfate, Anhydrous
Trisodium Phosphate
Tetrasodium Pyrophosphate (TSPP)
Sodium Tripolyphosphate

ACIDIZING
Hydrochloric (Muriatic) Acid
Hydrofluoric Acid
Sodium Bifluoride

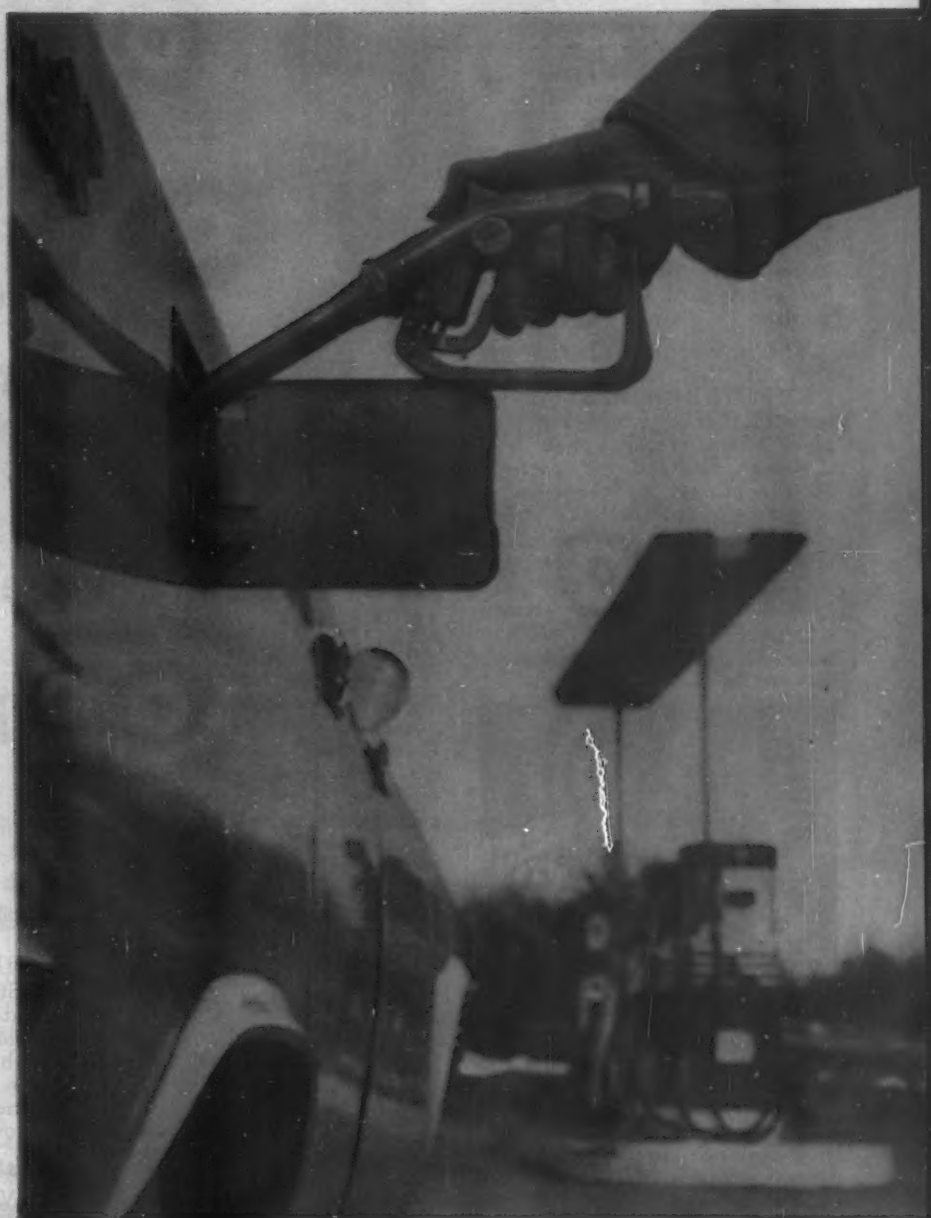
MUD CONDITIONING
Sodium Silicate
Disodium Phosphate
Trisodium Phosphate
Tetrasodium Pyrophosphate (TSPP)
Sodium Tripolyphosphate

GREASE MAKING
Aluminum Sulfate

ACID TREATING
Sulfuric Acid
Sodium Silicate

Other Heavy Chemicals, catalysts, addition agents, inhibitors and special "tailor-made" chemicals.

Baker & Adamson® Laboratory Reagents



Allied Chemical

Basic Chemicals for American Industry

GENERAL CHEMICAL DIVISION

40 Rector Street, New York 6, N. Y.

Offices: Albany • Atlanta • Baltimore • Birmingham • Boston • Bridgeport • Buffalo • Charlotte • Chicago • Cleveland (Miss.) • Cleveland (Ohio) • Denver Detroit • Houston • Jacksonville • Kalamazoo • Los Angeles • Milwaukee • Minneapolis • New York • Philadelphia • Pittsburgh • Portland (Ore.) • Providence San Francisco • St. Louis • Seattle • Kennewick, Vancouver and Yakima (Wash.) **In Canada: The Nichols Chemical Co., Ltd. • Montreal • Toronto • Vancouver**

For more data on advertised products, use Readers' Service Cards, last page.

New Invention Cuts Waste Disposal Costs By Two-Thirds in Petroleum Products Plants

Industry Cost Averages May Be Lowered Soon

If your plant is average, you're probably spending between .55 and .85 cents for every cubic yard of waste or trash moved to the disposal area . . . not including truck operation costs.

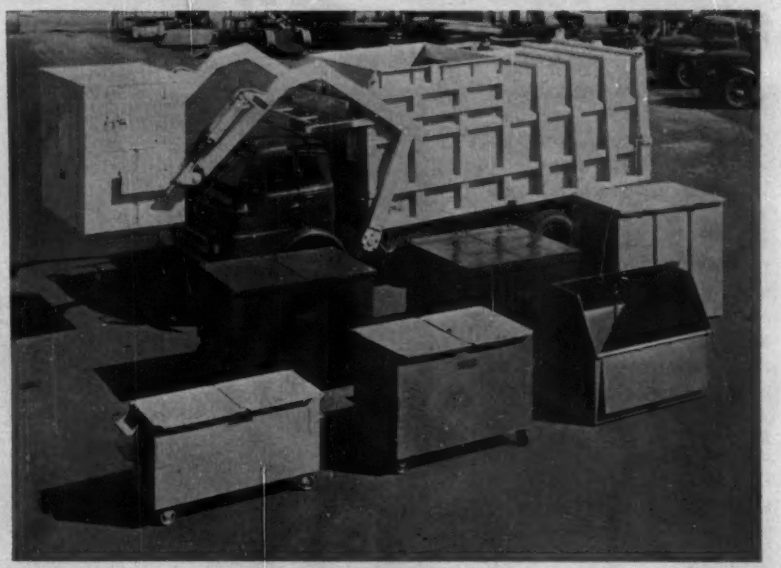
A recent development, the DEMPSTER-DUMPMASTER self-loading packer, promises to cut direct disposal costs to a new industry low of .07 to .16 cents per cubic yard for volume producers.

This new approach is an extension of the widely-established DEMPSTER-DUMPSTER System, in that it employs detachable waste storage containers. However, instead of carrying each container to the disposal area for dumping, the new machine empties many containers into its body, where the material is compacted to a fraction of its former volume. This permits per-trip payloads of 50 to 100 cubic yards of loose material, depending on its characteristics.

Multiple exposure photo shows dumping of 6 cu. yd. container.

How it Operates

The one-man Dumpmaster makes its rounds from container to container. Approaching, the driver engages lifting channels on the container's sides with the clearance arms. From controls in the cab, or remote controls at the front bumper, the container is lifted and rotated, discharging waste into the packer body. The material is hydraulically compacted while enroute to the next location. Containers may also be handled from docks or below grade. The safety clearance arms never pass the cab windows, eliminating possibility of driver injury.



The newly developed DEMPSTER-DUMPMASTER is shown with the seven basic containers it serves. Being hoisted is a 6 cu. yd. model. On ground are 1, 2, 3, 4 and 5 cu. yd. designs. Open container is used for hand-loading service.

New "Tracking" Caster Developments Make Plant "Container Trains" Practical

To whip the high cost of moving refuse outside, many plants are going to "container trains." Using special casters and couplers, eight to ten containers are towed by "plant mules" to inside generation points where an empty is dropped off and the full one is coupled on. Outside, the containers are uncoupled and automatically emptied by the waiting DUMPMASTER.

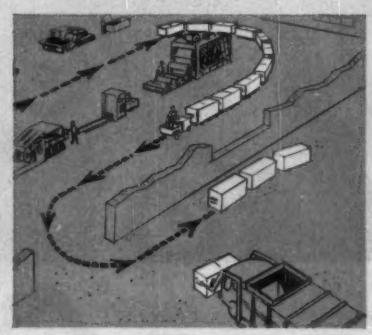


Diagram shows containers, in train, being hauled outside for emptying.

* * *

Many Designs Available

Standard and special-purpose containers, ranging from one through six cubic yard capacity, with or without casters, are available. The two cubic yard container above holds the equivalent of over 12 30-gallon trash cans.

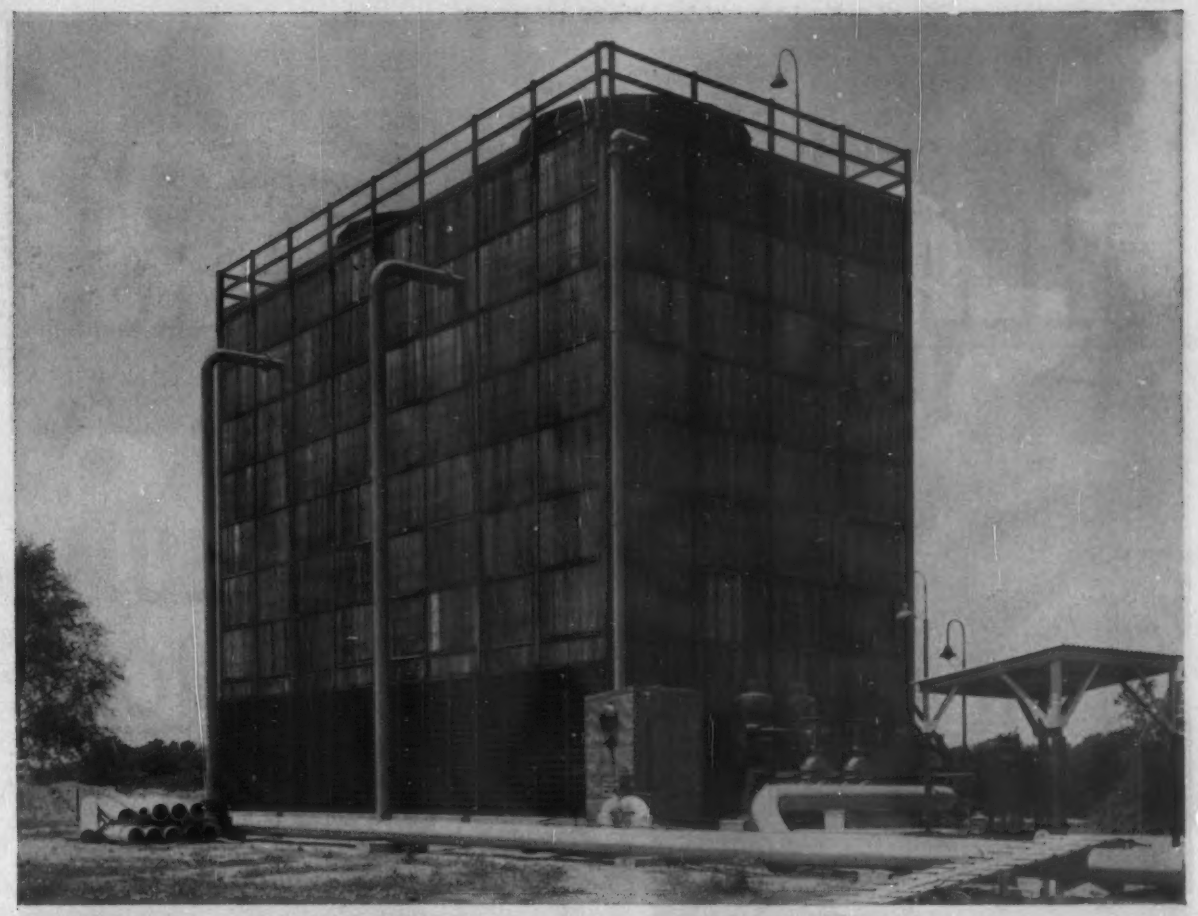
Cost-Finding Book Offered

Write for the free 40-page book, "How to Cut Waste Disposal Costs," offered by the manufacturer. It contains cost-finding formulas, solutions to problems, case histories, industry average costs, etc. Equipment demonstrations arranged on request.

Mfd. by Dempster Brothers, Inc.

DEMPSTER BROTHERS

KNOXVILLE, TENN., DEPT. PR-5



HOW TO FIGHT CORROSION IN COOLING TOWERS

The sure way to prevent corrosion of metal in cooling towers is to add Mutual Sodium Bichromate or Sodium Chromate to the cooling water. Whether used alone or in combination with other chemicals, chromates form a thin, protective film which combats corrosion due to anodic action, as well as making waters non-corrosive.

Wooden cooling towers will resist rot and insect damage if built with chromate-treated lumber. Existing towers built of untreated lumber can be protected by first spraying with copper sulfate solution, then with a sodium chromate solution.

Our Technical Service Staff will be pleased to assist you in solving corrosion problems in cooling towers. Delivery of Mutual Chromates is rapid, reliable. Write or phone today for this expert service, and for the informative bulletins listed below.

Mutual chromium chemicals

Sodium Bichromate
Sodium Chromate
Chromic Acid
Potassium Bichromate
Potassium Chromate
Ammonium Bichromate
Koreon (one-bath chrome tan)

SOLVAY PROCESS DIVISION
61 Broadway, New York 6, N. Y.

Allied Chemical

MUTUAL chromium chemicals are available through dealers and SOLVAY branch offices located in major centers from coast to coast.

Solvay Process Division
Dept. 23, 61 Broadway, New York 6, N. Y.

Please send:

- ☐ Bulletin 55—Corrosion Inhibition with Chromates in the Oil and Gas Industries.
- ☐ Bulletin 53—Corrosion Inhibitors in Recirculating Water Systems.
- ☐ Bulletin 35—Corrosion Control in Air Conditioning.

NAME_____ TITLE_____

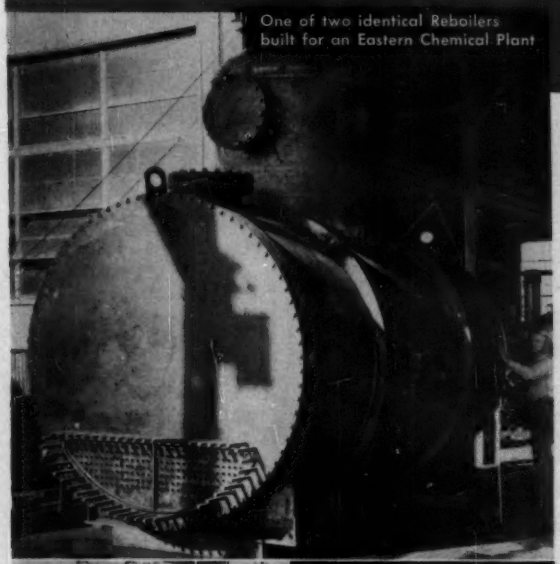
COMPANY_____

STREET_____

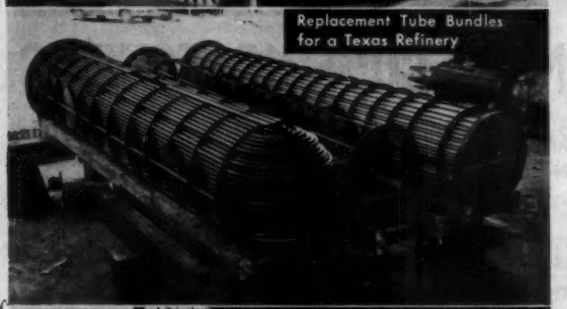
CITY_____ ZONE____ STATE_____

For more data on advertised products, use Readers' Service Cards, last page.

A Superior Service for HEAT EXCHANGERS



One of two identical Reboilers built for an Eastern Chemical Plant



Replacement Tube Bundles for a Texas Refinery

Texas Metal Exchangers for a Canadian Chemical Plant

for the

PETROLEUM and CHEMICAL Industries

Performance engineered to fit YOUR heat transfer needs.

DESIGN
REPAIR
FABRICATION

Your inquiries are cordially invited.

MTF

TEXAS METAL FABRICATING COMPANY

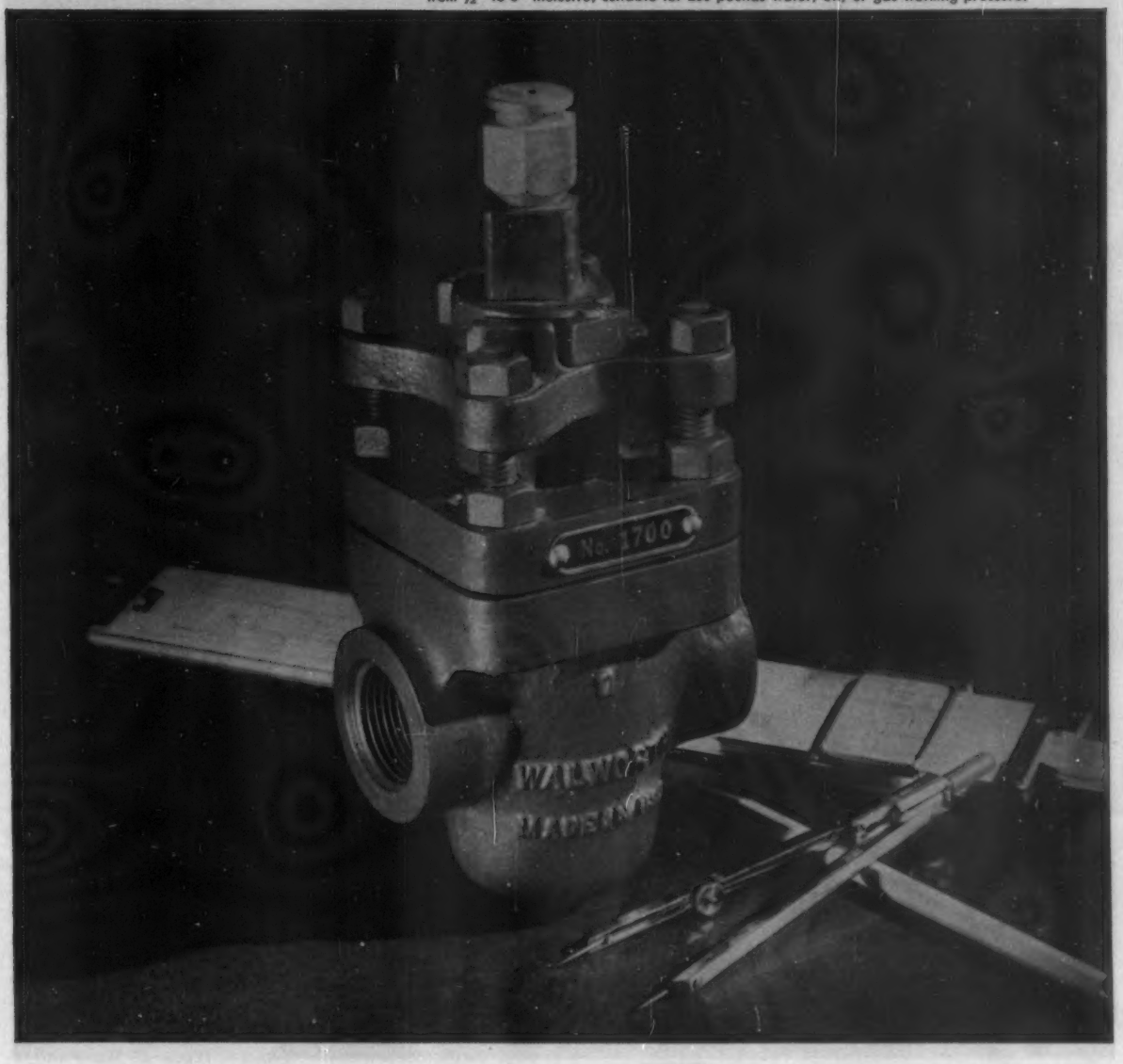
HOUSTON

ASME Code Construction

Qualified for Construction in Ferrous and Non-Ferrous Materials

Our Tenth Anniversary of Service to the Petro-Chemical Industry

Illustrated here is the Walworth Lubricated Plug Valve No. 1700, available in sizes from ½" to 5" inclusive, suitable for 200 pounds water, oil, or gas working pressure.



problem-solvers for tough jobs

*LPV's by WALWORTH

If you're familiar with the basic advantages of Plug Valves, you know why Walworth Lubricated Plug Valves work so well in really tough spots. You know about their direct port opening . . . their dead tight shut off. Seating and sealing surfaces are fully protected from attack by fluids being handled by insoluble lubricants.

*Lubricated Plug Valves

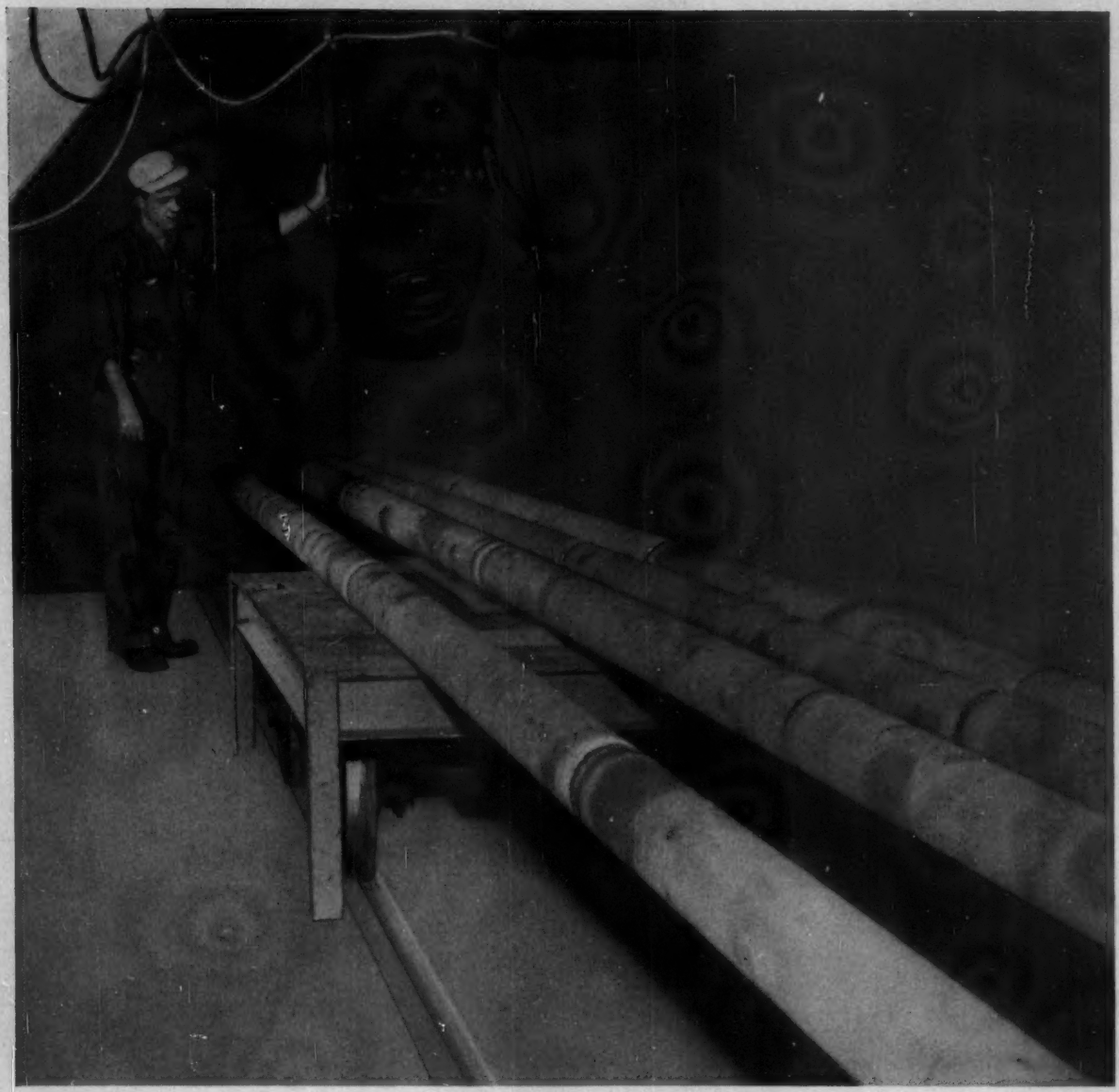
Remember, you can get Walworth LPV's in all sizes . . . from ½ to 30 inches . . . for pressures up to 5000 psi and for vacuum service . . . in a number of different styles and patterns. For more information about LPV's and for your copy of the new Walworth LPV Circular, see your local Walworth Distributor.

WALWORTH

750 THIRD AVENUE, NEW YORK 17, N. Y.

DISTRIBUTORS IN PRINCIPAL CENTERS THROUGHOUT THE WORLD

WALWORTH SUBSIDIARIES: ALLOY STEEL PRODUCTS CO. • CONOFLOW CORPORATION • GROVE VALVE AND REGULATOR CO. SOUTHWEST FABRICATING & WELDING CO., INC. • M&H VALVE & FITTINGS CO. • WALWORTH COMPANY OF CANADA, LTD.

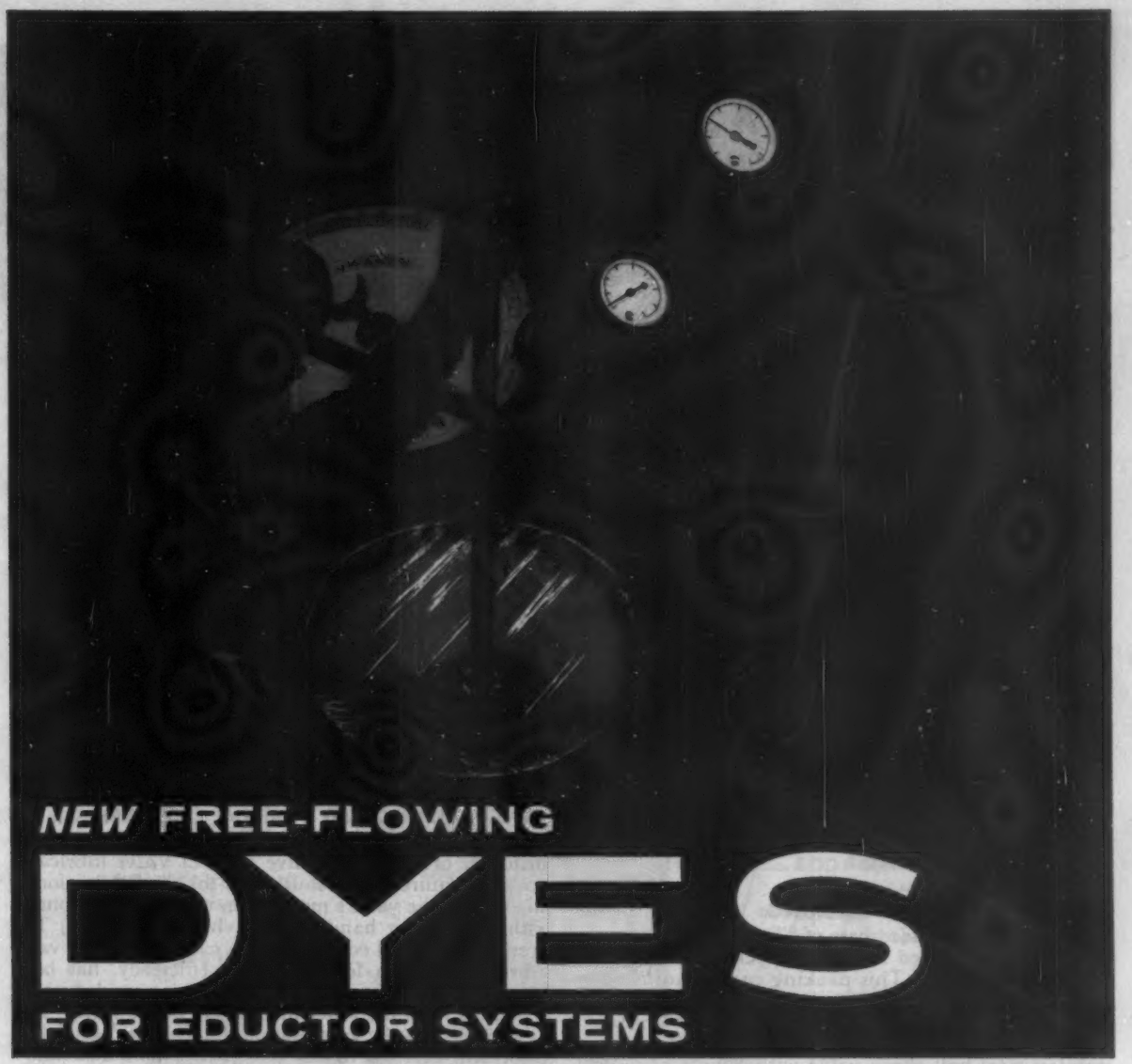


"Double and redoubled inspection" to guarantee leak-proof service— ELECTRO-ALLOYS Reformer Furnace Tubes!

Individual tubes are *hydrostatically* tested. Tubes are *dy-cheked* after every weld pass. Complete assemblies are *X-rayed* and then given a final *pressure test*. This is positive protection against leaks that might some day save you a fortune. Add greater density, finer grain structure, uniform wall thickness... and you understand why Thermalloy* centrifugally cast tubes are preferred. When you think in terms of tubes, think Thermalloy... and put Electro-Alloys' long metallurgical experience in heat-resistant alloys to work for you. Call your nearby representative—or write Electro-Alloys Division, 9075 Taylor Street, Elyria, Ohio. *Reg. U. S. Pat. Off.

Brake Shoe COMPANY

ELECTRO-ALLOYS DIVISION • Elyria, Ohio



NEW FREE-FLOWING DYES FOR EDUCTOR SYSTEMS

From coast to coast leading petroleum refineries look to the Koppers Company (formerly American Aniline Products) for the best in micro-fine dyes that will flow freely through modern eductor equipment. Available in a full range of brilliant shades, Koppers colors for the petroleum industry meet the most exacting refinery specifications for tinctorial strength and guaranteed lot-to-lot uniformity. New Vu-Dye Top on every drum prevents needless dusting, assures dry, lump-free dyestuff at all times, enables operator to watch level of drum contents as material is used. For working samples and technical assistance, consult our nearest branch.

YOURS FOR THE ASKING...
Valuable sample and laboratory evaluation kit with latest shade additions.

KOPPERS

Koppers Co., INC.

CHEMICALS & DYESTUFFS DIVISION

KOPPERS BUILDING, PITTSBURGH 19, PA. **Plants:** LOCK HAVEN, PA. **Branches:** Providence, R. I. • Philadelphia, Pa. • Paterson, N. J. • Chicago, Ill. Charlotte, N.C. • Chattanooga, Tenn. • Columbus, Ga. • Los Angeles, Cal. • Houston, Texas • **Dominion Anilines & Chemicals, Ltd.,** Toronto, Canada

Please rush **FREE** laboratory kit of Koppers Oil Colors to:

NAME.....

FIRM.....

POSITION.....

ADDRESS.....

Mail to Pittsburgh office or nearest branch. Our local representative is ready to provide full information and technical advice at any time.

For more data on advertised products, use Readers' Service Cards, last page.

NOW AVAILABLE—THE NEW AND IMPROVED ORBIT FORGED STEEL ASA CLASS VALVE

The new and improved Orbit ASA class valve is equal to a stainless trimmed valve in quality — yet, it is priced to compete with other makes of carbon trimmed valves.

• **NON-TURBULENT FLOW:** In an open position the Orbit valve presents a full round straight through smoothly machined bore. There are no voids or cavities in the body or bonnet where pressures can build up from trapped fluids when the valve is either in an open or closed position.

• **RISING STEM:** A definite advantage because the operator can tell at a glance whether the valve is open or shut.

• **ALL FORGED STEEL VAPOR TIGHT CONSTRUCTION:** Forgings are known to represent the ultimate material for pressure equipment; because of this, flaws, cracks and porous metal structures have been eliminated.

• **WELDED BONNET:** Here the inherent safety of welded pressure vessels is recognized. This feature has been included in the Orbit valve by welding the bonnet to the body, which also strengthens the body and bonnet assembly so that they are not affected by vibrations or fluctuating temperatures. The use of bonnet gasketing materials which are subject to wear and attack from corrosion, from line fluids, or from atmospheric conditions have been eliminated.

• **ADJUSTABLE STEM PACKING:** A pliable plastic packing with a shredded base of "Teflon,"* that is easily extruded, is provided as a stem packing in all Orbit forged steel valves. This packing can be adjusted or added to while the valve is in service and under pressure. Additional features include a replaceable threaded bushing for the adjustment screw and a positive seating stainless steel ball check valve with a wide angle exit into the chamber to hold back-pressures while adding new packing. The packing adjustment chamber is set at a 45° angle to provide, besides easy access, a straight flow to main packing chamber. Restrictive passages have been eliminated. "Teflon"* lip-type packing retainer rings are provided at the top and bottom of the packing chamber to reduce stem friction and to offer greater latitude as a pressure seal. This new and improved Orbit forged steel valve has an enlarged packing chamber with greater depth and capacity for easier adjustment and longer life of the packing.

• **STAINLESS STEEL TRIMMED:** All working parts that are exposed to fluid flow are made entirely of or are trimmed with stainless steel. All materials have been up-graded to assure maximum corrosion resistance for the valve's recommended services and to reduce wear on the working parts. All of this has been accomplished with no additional cost to our customers through the efforts of our engineering staff, research department and completely modernized plant facilities.

• **SUPER-FINISHED STEMS:** Stems are made of heat treated stainless steel. All stems are super-finished and are coated with molybdenum disulphide on the lower trunnions to eliminate the necessity of lubrication below the packing chamber.

• **PHYSICAL DESIGN:** The forged steel body and bonnet and welded construction are combined to give the Orbit valve a compact design, a modern streamlined look and reduced weight which allows installation in a minimum of space.

• **NON-LUBRICATED POSITIVE CLOSURE:** Some of the advantages offered by the friction free seating principle of the Orbit Valve are: (1) Valve lubricants are not required for a shut-off or for the lubrication of any part of the valve's mechanism that comes in contact with fluid being handled in cavity of valve. (2) The possibility of fluid contamination carry-over from valve lubricants, which lower catalyst efficiency, has been eliminated. Only one lubrication point is provided which is isolated from the lower mechanism of the valve. This lubricates only the guide pin and handwheel assembly. Lubricant does not in any way enter the fluid stream.

• **HANDWHEELS:** Removable Type. Orbit's new finger grip helm type handwheel delivers maximum effectiveness with minimum effort. The operator can get a firm grip even with wet or greasy hands. Helm type handwheel remains cooler for the operator's hands. Handwheels are made of malleable iron, have great strength and will last the lifetime of the valve.

* Registered trademark for du Pont's tetrafluorethylene resin.

WRITE FOR CATALOG 58-B—DEPARTMENT A

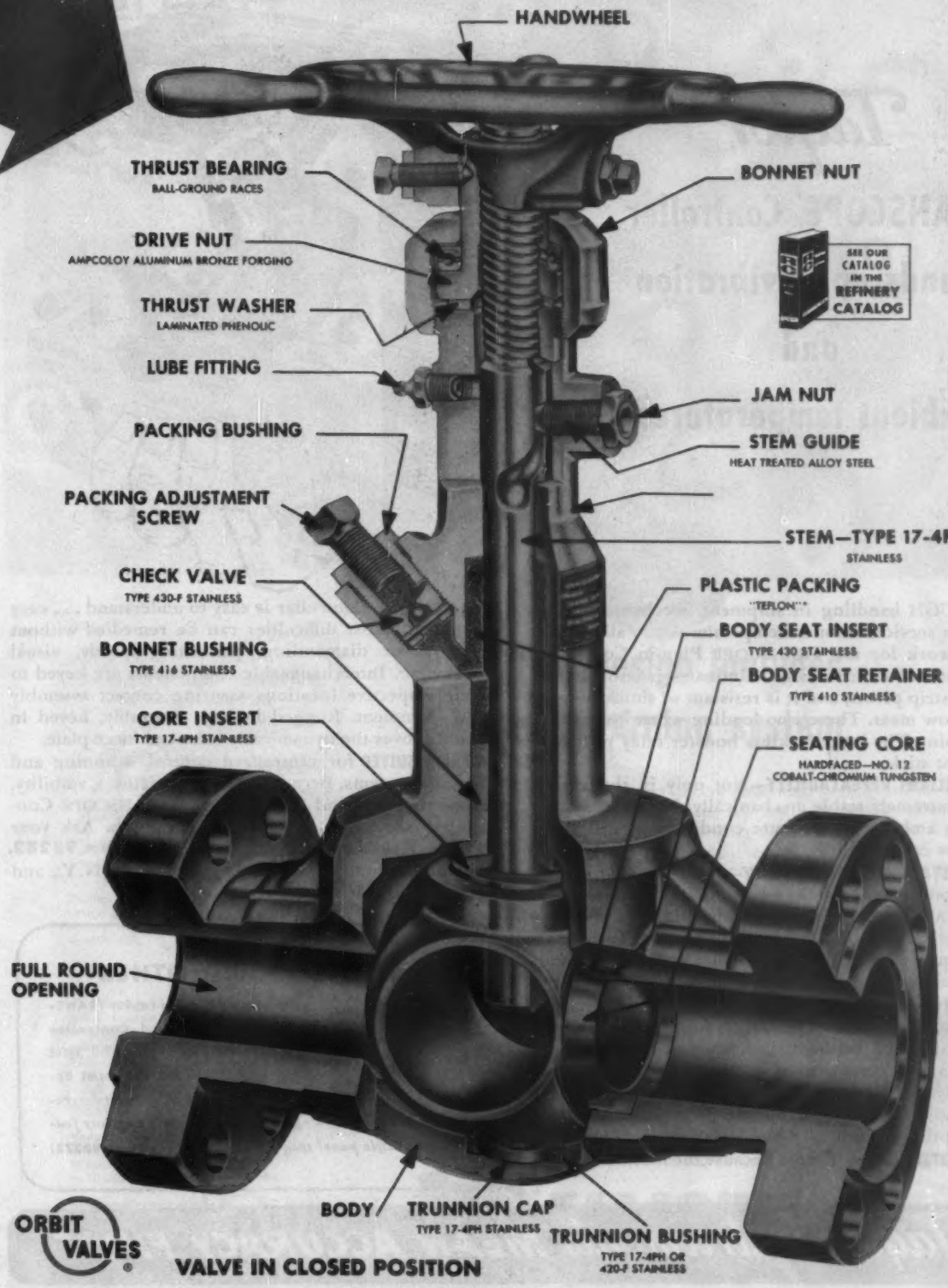
ORBIT VALVE COMPANY

P. O. BOX 699
TULSA, OKLAHOMA

Phone LUther 4-4761 TWX TU 925

WAREHOUSES: HOUSTON, TEXAS, 407 Velasco, CApitol 8-6623, TWX HO 115; ODESSA, TEXAS, 402 West County Road, FEderal 7-2263, TWX ODESSA TEX 8041; LAFAYETTE, LOUISIANA, 3111 Cameron St., CEnter 4-3326; EDMONTON, ALBERTA, CANADA, 7119-104th St., Phone 391-283. WEST COAST REPRESENTATIVE: Fred P. Koenig Company, Long Beach, Calif., 3815 Atlantic Avenue, GArfield 4-3834. CANADIAN REPRESENTATIVE: T. R. Pickford & Company, Ltd., Calgary, Alberta, 309 7th Avenue West, AMherst 2-7371. EXPORT REPRESENTATIVE: New York 36, N. Y., 500 Fifth Avenue, BRyant 9-2236.

The new and improved Orbit ASA class valve has been made possible through complete modernization of manufacturing facilities and standardization of parts—resulting in increased valve production, upgrading of materials and quality and improving the Orbit valve's operating characteristics. Orbit Valve Company is passing on these new features as a savings to its customers—the savings being represented in prices.



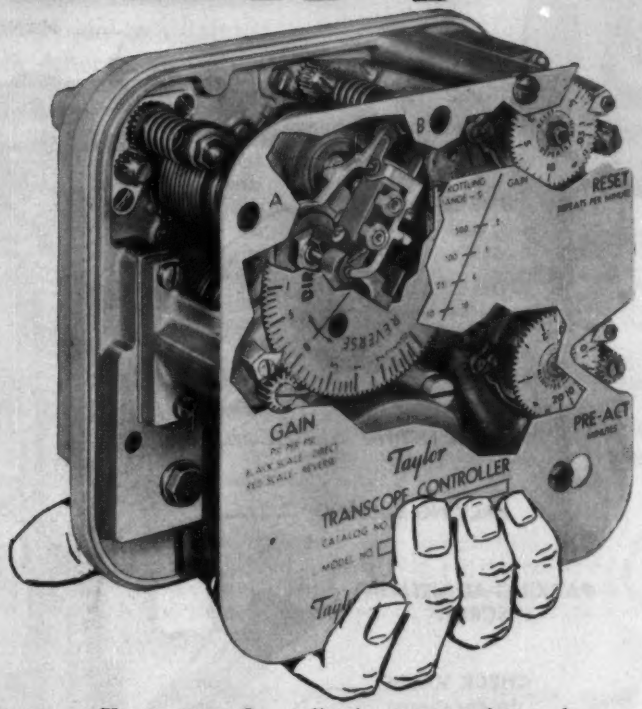
ORBIT VALVES

VALVE IN CLOSED POSITION

NO DRIFT

Taylor

TRANSCOPE* Controller stands up to vibration and ambient temperatures



ROUGH handling in shipment, mechanical abuse in service, ambient temperatures . . . all are in a day's work for the TRANSCOPE Plug-in Controller. Its motion-balance design eliminates friction by the use of strip pivots, and it is resistant to shock because of its low mass. There's no loading when it's on control point. The large leakless booster relay positively will not stick.

1. EXCELLENT REPEATABILITY—Not only is the instrument extremely stable mechanically, but under widely *varying* ambient temperature conditions it still maintains its repeatability.

2. OUTSTANDING ADAPTABILITY—As well as providing all response adjustments for immediate requirements, the TRANSCOPE Controller can be quickly and simply adapted to changes in operating conditions or processing requirements. Result: minimum inventory of interchangeable spare parts.

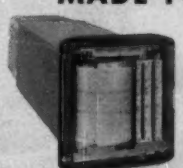
3. HIGHLY ACCURATE RESPONSE SETTINGS—Precision manufacture of gain, reset and PRE-ACT* units permits pre-determined mathematical settings. Same settings in different instruments give same results—extremely valuable on preventative maintenance. Most accurate pneumatic settings available. Response to adjustments is exceptionally fast . . . a big "plus" on start-ups.

4. MAINTENANCE is simple because the motion-balance TRANSCOPE Controller is easy to understand . . . easy to get at. Most difficulties can be remedied without removal or dismantling, permitting speedy, visual alignment. Interchangeable components are keyed to their respective locations assuring correct assembly and alignment. Rugged bellows assembly, keyed in place, moves the dynamically balanced force plate.

IDEALLY SUITED for centralized control, scanning and logging systems. Because of its compactness, stability, responsiveness and simplicity, the TRANSCOPE Controller is a match for your toughest job. Ask your Taylor Field Engineer, or write for **Form No. 98282.** Taylor Instrument Companies, Rochester, N.Y., and Toronto, Ontario.

*Trade-Mark

MADE FOR EACH OTHER



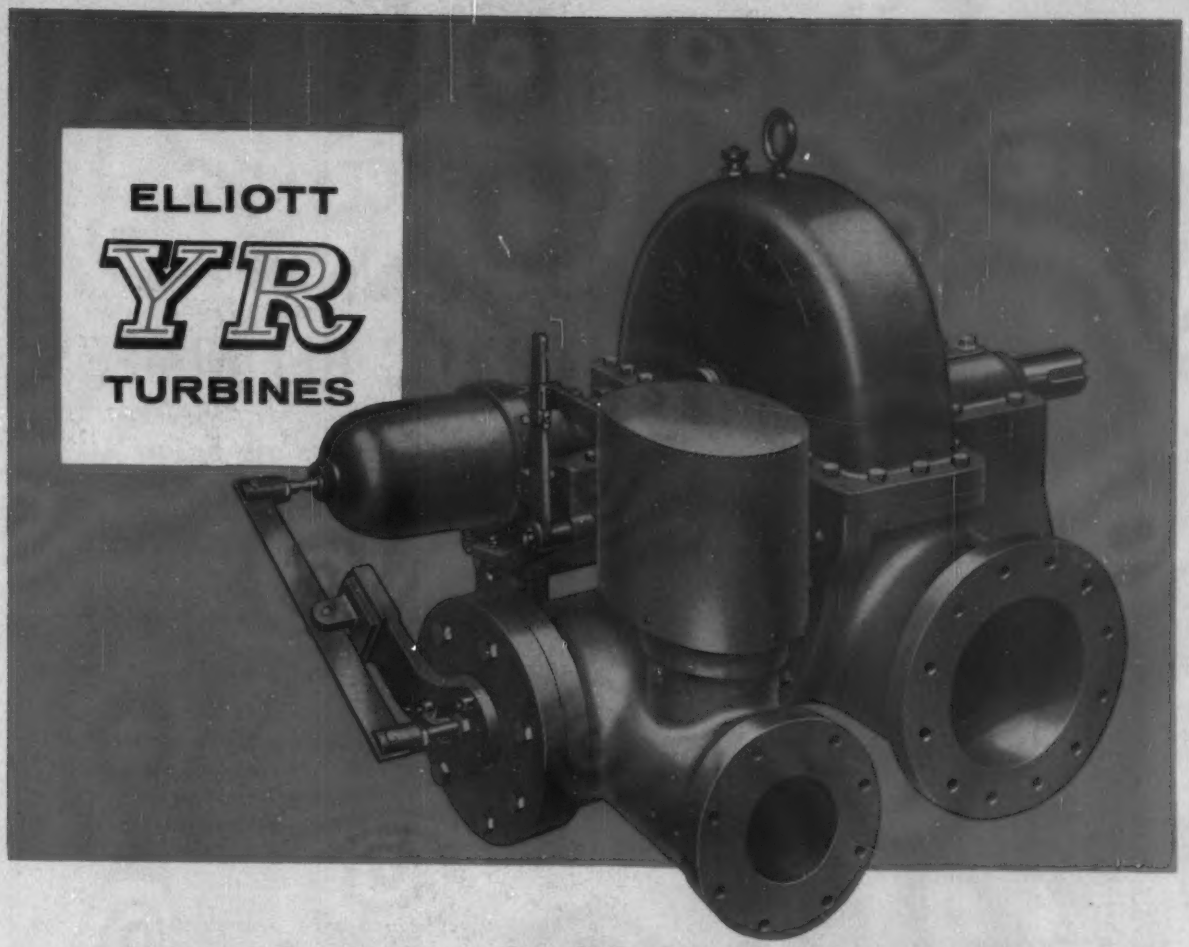
The combination of Taylor TRANSCOPE Recorder and Controller gives your operators the best tools possible for the most exacting jobs. *No other recorder, regardless of size, puts so many features in so little panel space.* Write now for **Form 98272.**

Taylor Instruments **MEAN ACCURACY FIRST**

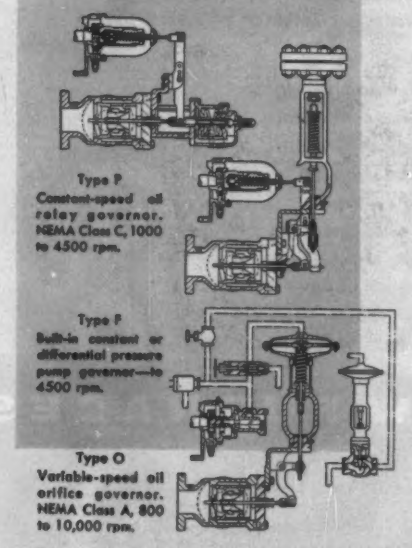
ELLIOTT

YR

TURBINES



YOUR CHOICE OF DESIGN MODIFICATIONS TO MATCH YOUR SPECIFIC APPLICATION REQUIREMENTS



Type P
Constant-speed oil relay governor. NEMA Class C, 1000 to 4500 rpm.

Type F
Built-in constant or differential pressure pump governor—to 4500 rpm.

Type O
Variable-speed oil orifice governor. NEMA Class A, 800 to 10,000 rpm.

Other modifications include electric and pneumatic remote trip, high back-pressure trip, electric and pneumatic speed changer, low oil pressure trip, special shaft extensions, and various accessories.

simplified design includes reliable governing system

The Elliott-engineered, direct-acting governing system with over-speed trip and valve (NEMA Class A) positively insures smooth uniform speed 24-hours-a-day, day-after-day, year-after-year. The horizontal, fly-ball-type, speed-sensitive element is effectively weather-proofed by an aluminum enclosure . . . mounted on the end of the turbine shaft and directly connected to the steam admission valve by a sturdy linkage. Mica-impregnated packing and a flexible, non-aging Neoprene grommet insure an effective steam seal over long operating periods.

Other design benefits of Elliott single-stage turbines are easy inspection . . . simple replacement of wearing parts . . . and interchangeable components from one turbine frame to another. And always near you is your Elliott field engineer. For full details write Elliott Company, Steam Turbine Department, Jeannette, Pa. Ask for Bulletin H-22B.

day-in/day-out service

ELLIOTT Company

HB-1

STEAM TURBINES • MOTORS • GENERATORS • DEAERATING HEATERS • EJECTORS • CONDENSERS • CENTRIFUGAL COMPRESSORS • TURBOCHARGERS • TUBE CLEANERS • STRAINERS

ISOFLOW FURNACES NOW PROCESSING 300,000 b/d IN CATALYTIC REFORMERS

. . . and more "Isoflows" are being installed in the largest reformers under construction

The continuous production of high octane gasoline by catalytic reforming demands sturdy, efficient, soundly designed equipment. This is especially true of furnaces.

The wide acceptance of Petrochem-Isoflow furnaces is due to their high efficiency, dependable performance even under overload conditions, and their long service life. When you apply all the specifications and operating requirements to direct fired furnace design you'll find Petrochem-Isoflows most economically desirable, by any comparison.

For petroleum, chemical and allied process industries there's a Petrochem-Isoflow furnace for any duty, temperature and efficiency.

The unique design and operating features which have led to the wide acceptance of Petro-Chem furnaces include:

- Uniform Heat Distribution
- Maximum Fuel Efficiency
- Low Pressure Drop
- Low Maintenance
- Zero Air Leakage
- Minimum Ground Space
- Simplicity of Design and Construction
- Short Length of Liquid Travel
- Series, Multipass, all parallel flow
- Excess Draft for High Overload

PETROCHEM-ISOFLOW FURNACES

UNLIMITED IN SIZE . . . CAPACITY . . . DUTY

PETRO-CHEM DEVELOPMENT CO., INC. • 122 EAST 42nd St., New York 17, N. Y.

REPRESENTATIVES:

Dawson & Co., Houston & Baton Rouge • Wm. H. Mason Co., Tulsa • Lester Oberholtz, Los Angeles • Saville-Lovally, Chicago
D. J. Foster, Pittsburgh • Torbex, Philadelphia • Flagg, Brackett & Durgin, Boston • G. W. Wallace & Co., Denver & Salt Lake City

International Licensees and Representatives: SETEA—S.A. Comercial, Industrial y de Estudios Tecnicos, Buenos Aires, Argentina • Industrial Proyectos, Caracas, Venezuela • Societe Anonyme Heurtey, Paris, France • Societe Anonyme Belge, Liege, Belgium • Petrochem G.M.B.H., Dusseldorf, Germany • Heurtey Italiana S.P.A., Milan, Italy • Birwelco Ltd., Birmingham, England

In this refinery of the Cities Service Oil Company, "Telvar", applied in May, kept area weed-free entire season. Throughout the oil industry, fire hazards and maintenance problems are greatly reduced by weed control with "Telvar".

Avoid fire hazards . . . reduce maintenance costs . . . control weeds all season with one spraying.

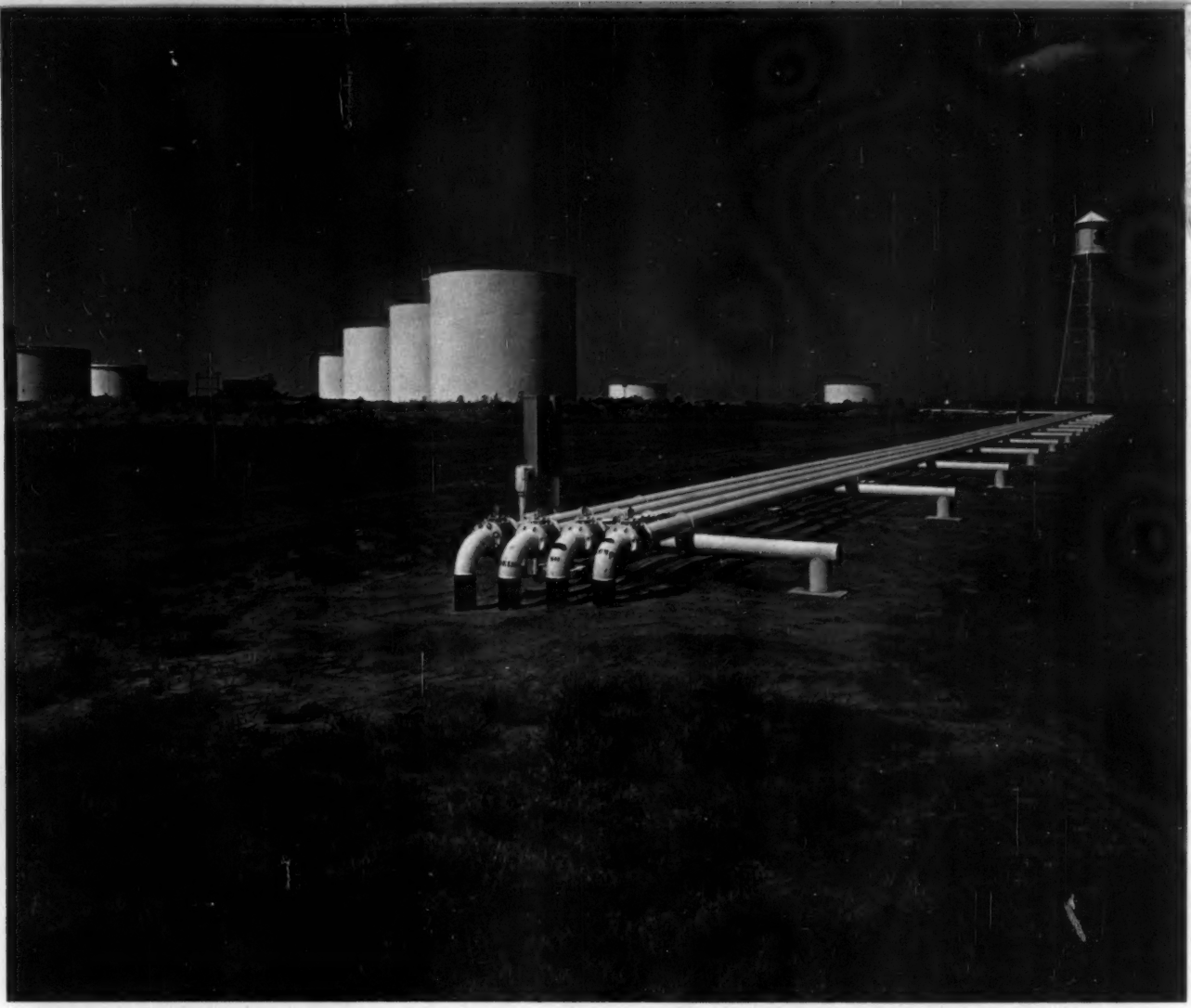
Now you can eliminate weeds and grasses that create fire hazards and make maintenance difficult. Just one application of Du Pont "Telvar" weed killer controls weeds for a season or longer.

"Telvar" kills weeds through the roots . . . remains in the soil to provide residual action. Easy to handle, economical to use. Be sure to specify "Telvar" . . . for long-term weed control.

E. I. DU PONT DE NEMOURS & CO. (INC.)
GRASSELLI CHEMICALS DEPARTMENT
WILMINGTON 98, DELAWARE

In Canada: 85 Eglinton Avenue, East
Toronto 12, Ontario

TELVAR
MONURON AND DIURON
WEED KILLERS



Note the complete control of vegetation from "Telvar" around these overground lines of the Phillips Petroleum Company. "Telvar" was applied in March, photo taken four months later. Around pipe lines, refineries, tank farms and producing wells, "Telvar" eliminates fire-hazardous vegetation.

"Telvar" W monuron weed killer was applied around this producing well of the Phillips Petroleum Company in April and the photo was taken five months later. "Telvar" can be applied in producing fields without damage to property or a hazard to livestock.

"Telvar" Weed Killers are convenient to use. They are low in toxicity to humans and animals and are non-volatile, non-corrosive, and non-flammable. They can be easily applied in standard spraying equipment, or if you prefer, custom applicators will do the job for you.

I want to know more about effective, low-cost, long-term weed control with Du Pont "Telvar" weed killers.

Name _____ Title _____

Firm _____

Address _____

_____

- For more information
- Name of nearest supplier

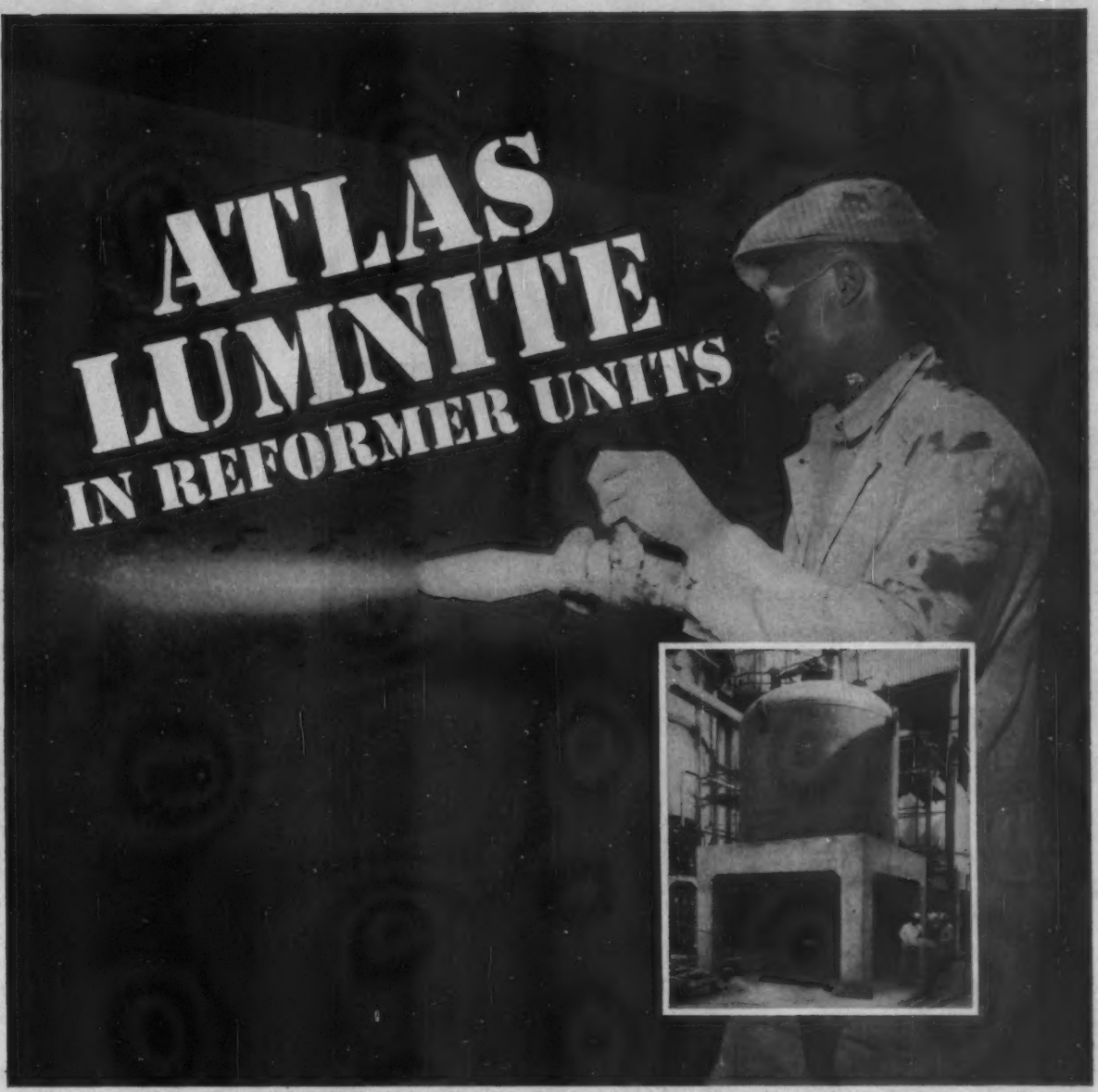
Mail this coupon to:

E. I. du Pont de Nemours & Co. (Inc.)
Room 2539-N, Wilmington 98, Del.

5967

PRINTED IN U.S.

ATLAS LUMNITE IN REFORMER UNITS



Guard chamber on Reformer Unit at Sinclair Refining Company's Marcus Hook (Penna.) refinery being gun-lined with refractory concrete (made with LUMNITE cement). Gunite Contractor: Joseph A. McCollum, Inc., Marlton, N. J.

insulates . . . resists heat . . . combats corrosion

- Industrial concrete linings (made with ATLAS® LUMNITE calcium-aluminate cement and suitable aggregates) help solve heat, corrosion and insulating problems in vital refinery equipment.
- Shutdown due to installation is minimized because placement is fast and easy — service strength is reached within 24 hours.

For maximum convenience, use castables made with LUMNITE® cement. These are packaged mixtures, ready for use. Simply add water, mix and place. Made and distributed by leading manufacturers of refractories.

For your copy of the "Lumnite Mortar Manual," describing gun-applied linings, write: Universal Atlas, 100 Park Avenue, New York 17, N. Y.

*ATLAS and LUMNITE are registered trade-marks. L-178

UNIVERSAL ATLAS CEMENTS

Universal Atlas Cement Company

Subsidiary of **United States Steel**

USS

OFFICES: *Albany · Birmingham · Boston · Chicago · Dayton · Kansas City · Milwaukee · Minneapolis · New York · Philadelphia · Pittsburgh · St. Louis · Waco*

Share This Unequalled

Ⓐ

Iso-Kel (*8pp*). Details of a new isomerization process which gives greater flexibility and economy in making all grades of gasoline.

Ⓑ

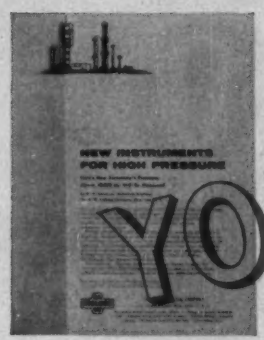
Kwinana Refinery (*16pp*). Details of the huge BP plant in Australia; its numerous offsite facilities; and how work was coordinated.

Ⓒ

Continuous Analysis (*8pp*). An instrument engineer reports on analyzers as a key to improved processing. Types of analyzers are described.

Ⓖ

Daura Refinery (*12pp*). A description of Iraq's Baghdad project, printed in Arabic, English, and Hindi. Emphasis is given to utilities problems.

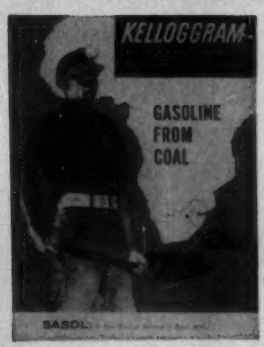


Ⓗ

New Instruments for High Pressure (*8pp*). A report from a leading instrument engineer as to how tomorrow's processes above 10,000 psi will be measured.

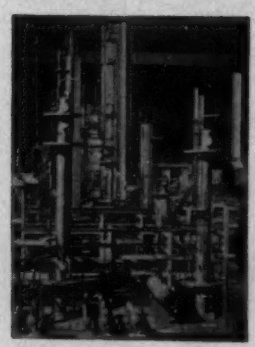
Ⓘ

Concon Refinery (*8pp*). Printed in Portuguese, Spanish, English, this account of Chile's first major refinery highlights design features and economics.



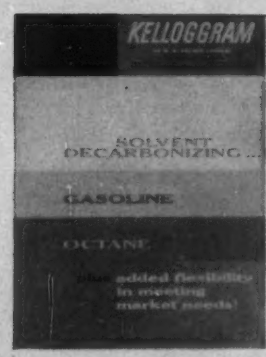
Ⓜ

Gasoline from Coal (*12pp*). This report on the world's largest commercial plant of its type gives details of process, yields, other pertinent facts.



Ⓝ

Models (*12pp*). A comprehensive description of the time-and-money-saving technique of using scale models as design tools. Many examples are illustrated.

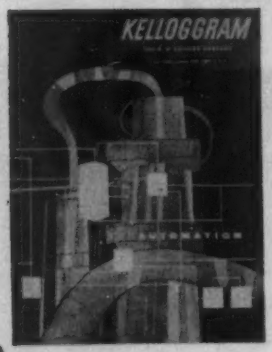


Ⓞ

Solvent Decarbonizing (*16pp*). A highly documented review of this flexible process for producing high octane and meeting varying market needs.

YOURS FOR

Engineering Experience

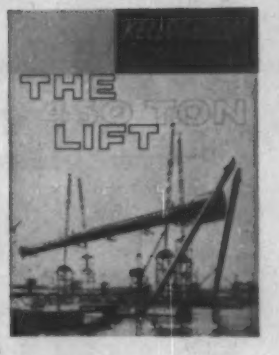


D

Automation (*16pp*). An easy-to-grasp treatise of a complex subject. Graphically explains automation and the instruments that make it work.

E

Hydrogen Sulfide Corrosion (*22pp*). A compilation of technical information on sulfide corrosion at high temperatures and pressures in the petroleum industry.



F

The 450 Ton Lift (*8pp*). A dramatic account, with photos taken on the spot, of the lifting and positioning of a Texas Tower. Diagrams show how it was engineered.

THE ASKING!

J

The Giant Step (*20pp*). From Kellogg's Defense Products Division, a guide for engineers facing technological problems in developing or producing defense materiel.

K

Yorktown Refinery (*16pp*). A record of cooperation in engineering and building a 35,000 BPD refinery for Amoco, including effluent treating facilities.

L

Calculation of Liquid-Vapor Equilibrium Constants from Solubility Data (*8pp*). One of many technical papers written for the chemical press by Kellogg engineers.

Among these 15 booklets and folders are many that Kellogg believes would be helpful to oil refiners and others. Largely a record of some of the company's engineering and construction work over the past few years, they cover a diversity of technological and economic problems and how they were solved.

Kellogg's Contract Sales Division welcomes the opportunity to share this valuable experience with others by sending, without charge, copies of any or all of the items listed to interested petroleum refiners or chemical companies. Requests will be filled in the order received, since the supply is limited. There is no obligation, but use of the coupon would be appreciated in order to facilitate handling.

CHECK ITEM REQUIRED AND SHOW QUANTITY ALONGSIDE

(Quantity will be filled according to supply)

A__	D__	G__	J__	M__
B__	E__	H__	K__	N__
C__	F__	I__	L__	O__

*Name*_____

*Title*_____

*Company*_____

*Address*_____

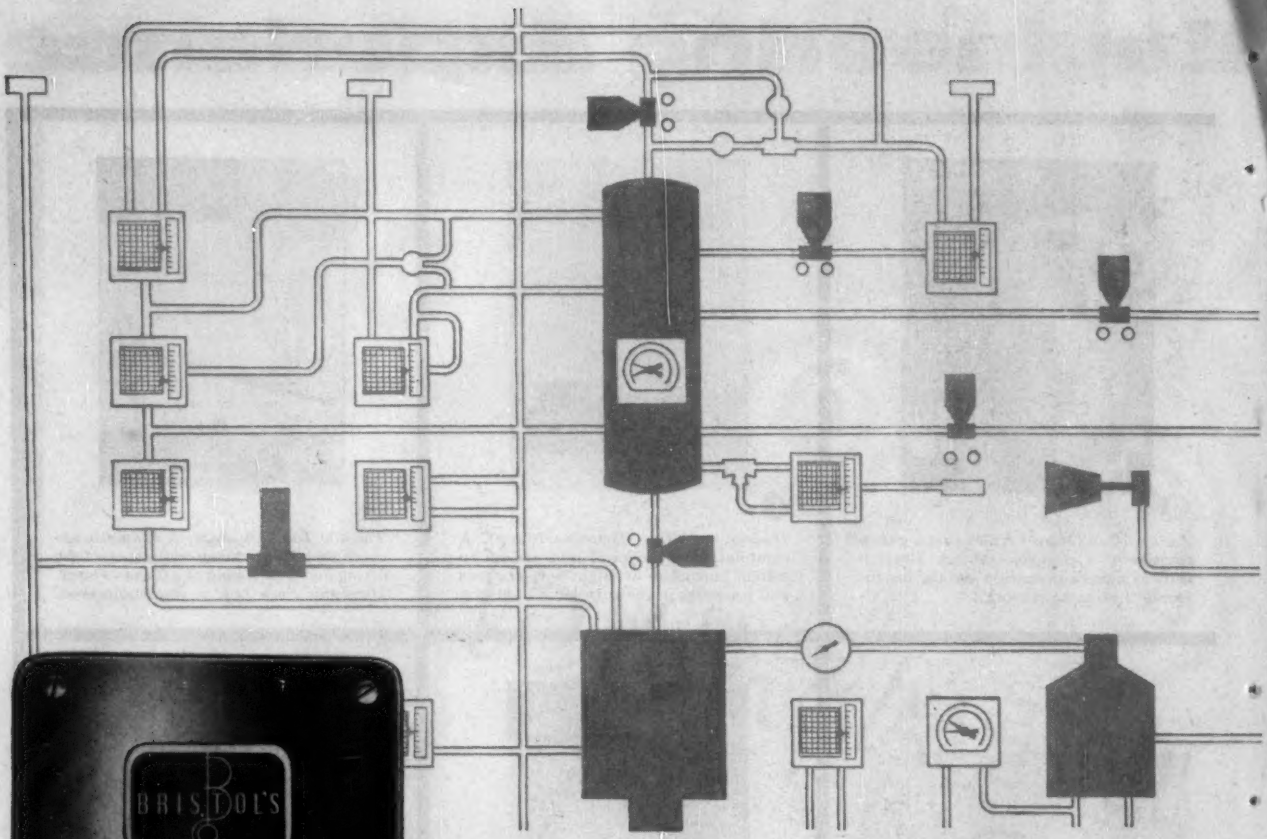
P.R. 5/58

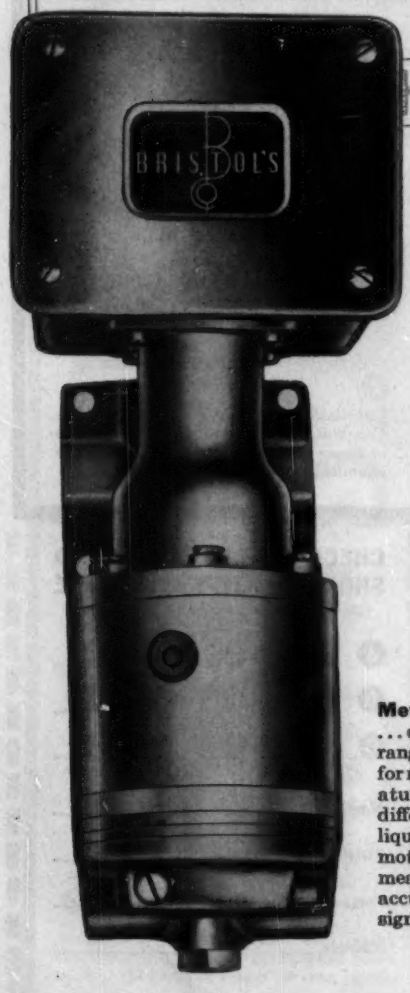
The M. W. Kellogg Company

711 Third Avenue, New York 17, N. Y.

A SUBSIDIARY OF PULLMAN INCORPORATED

The Canadian Kellogg Co., Ltd., Toronto • Kellogg International Corp., London
Kellogg Pan American Corp., New York • Societe Kellogg, Paris • Companhia
Kellogg Brasileira, Rio de Janeiro • Compania Kellogg de Venezuela, Caracas

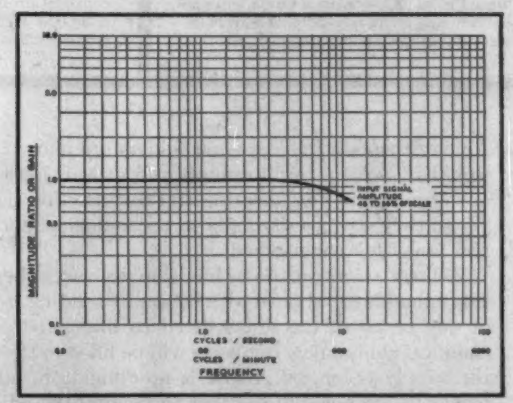




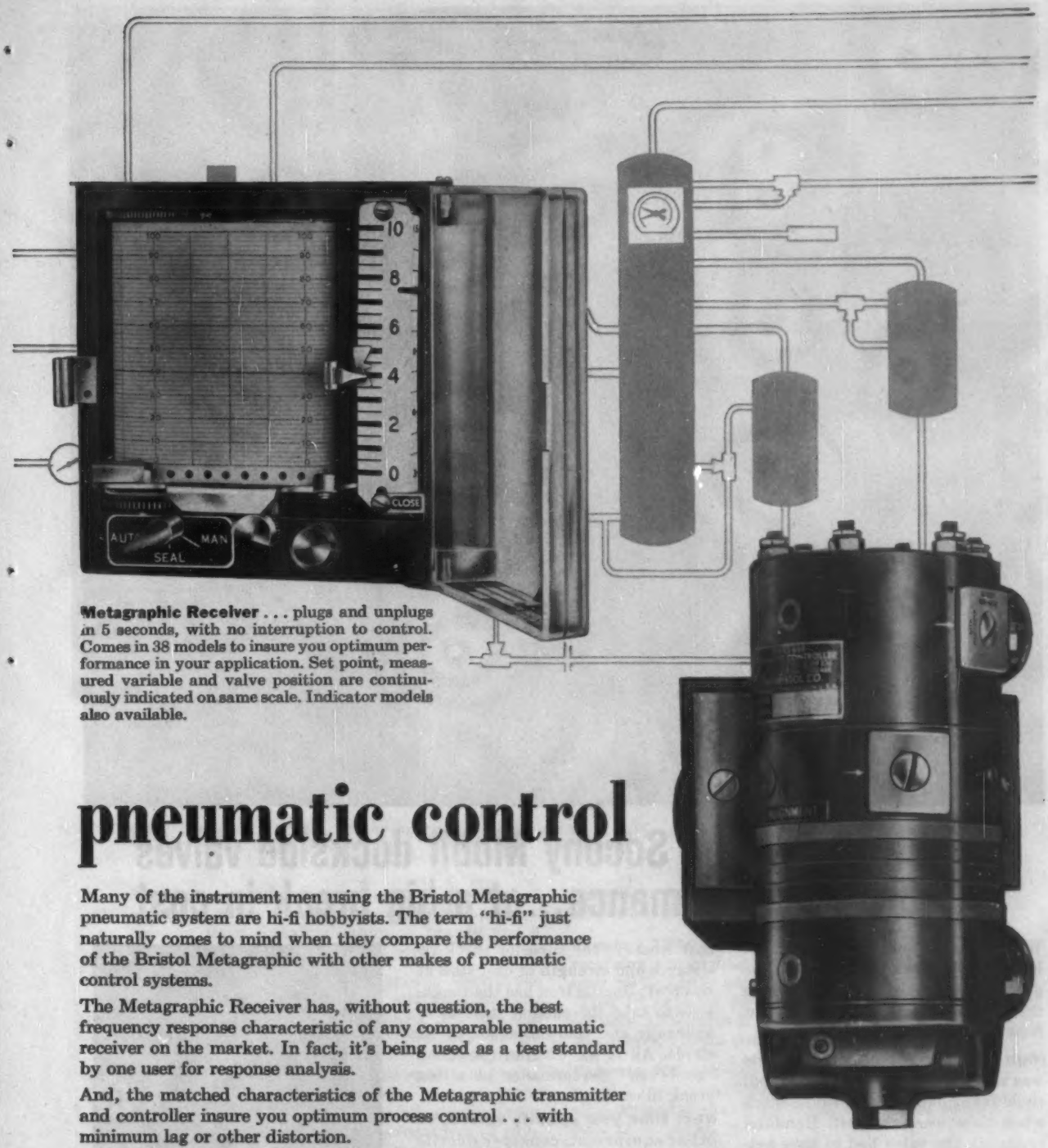
Why Bristol's Metagraphic System

gives you "Hi-Fi"

Metagraphic Transmitter ... offers you the broadest range and widest coverage for measurement of temperature, pressure, vacuum, differential pressure, flow, liquid level or mechanical motion. Standard Bristol measuring elements insure accuracy. 3-15 psi output signal.



Bristol Metagraphic Receiver frequency response is outstanding for a pneumatic instrument. At high end, the 70.7% response point occurs well above 10 cycles per second.



Metagraphic Receiver . . . plugs and unplugs in 5 seconds, with no interruption to control. Comes in 38 models to insure you optimum performance in your application. Set point, measured variable and valve position are continuously indicated on same scale. Indicator models also available.

pneumatic control

Many of the instrument men using the Bristol Metagraphic pneumatic system are hi-fi hobbyists. The term "hi-fi" just naturally comes to mind when they compare the performance of the Bristol Metagraphic with other makes of pneumatic control systems.

The Metagraphic Receiver has, without question, the best frequency response characteristic of any comparable pneumatic receiver on the market. In fact, it's being used as a test standard by one user for response analysis.

And, the matched characteristics of the Metagraphic transmitter and controller insure you optimum process control . . . with minimum lag or other distortion.

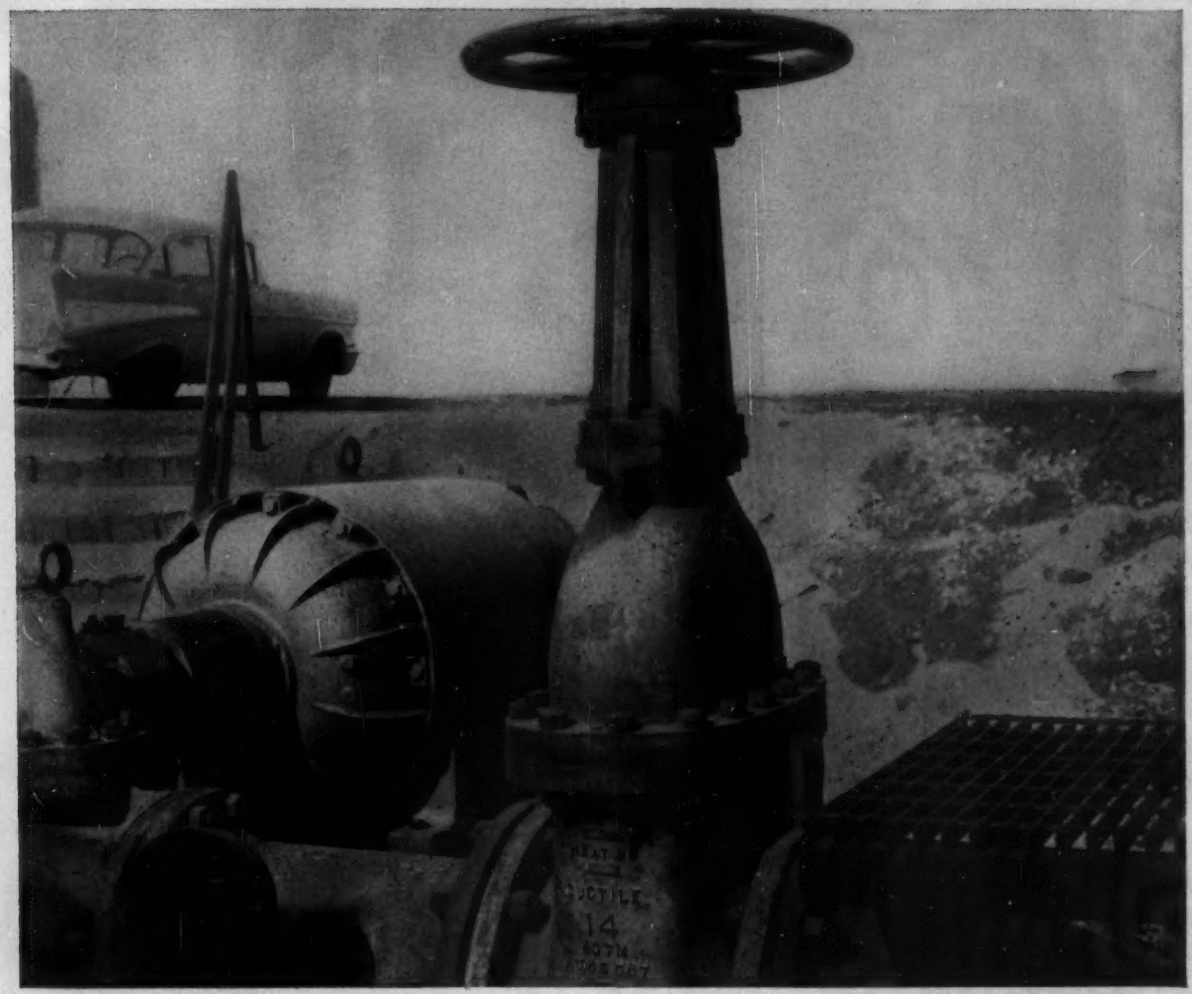
If your process needs the best in pneumatic control systems, get complete data on the Bristol Metagraphic. Our engineers will be glad to discuss, in detail, the characteristics of the Metagraphic system and how the system can be adapted to your particular requirements. The Bristol Company, 111 Bristol Road, Waterbury 20, Conn. B.S

Metagraphic Controller . . . this outstandingly rugged, trouble-free controller supplies precision pneumatic control of almost any variable. Operates from "universal" 3-15 psi pneumatic input signal. Proved force-balance operating principle requires almost no moving parts, nothing to wear out.

BRISTOL *TRAIL-BLAZERS IN PROCESS INSTRUMENTATION*

AUTOMATIC CONTROLLING, RECORDING AND TELEMETERING INSTRUMENTS

For more data on advertised products, use Readers' Service Cards, last page.



Ductile iron gives Socony Mobil dockside valves "no break" performance...at a big break in cost

When Socony Mobil needs a gang of husky valves, you can bet their engineers won't miss a trick. Such was the case at the company's Paulsboro, New Jersey Refinery wharf.

High on their list of requirements was the need for a type of valve that could take punishing hydraulic shock when lines were shut off. Handling crude oil, the valve had to have better than average corrosion resistance. And thermal shock, too, was an important consideration—a safety factor in case of refinery fire.

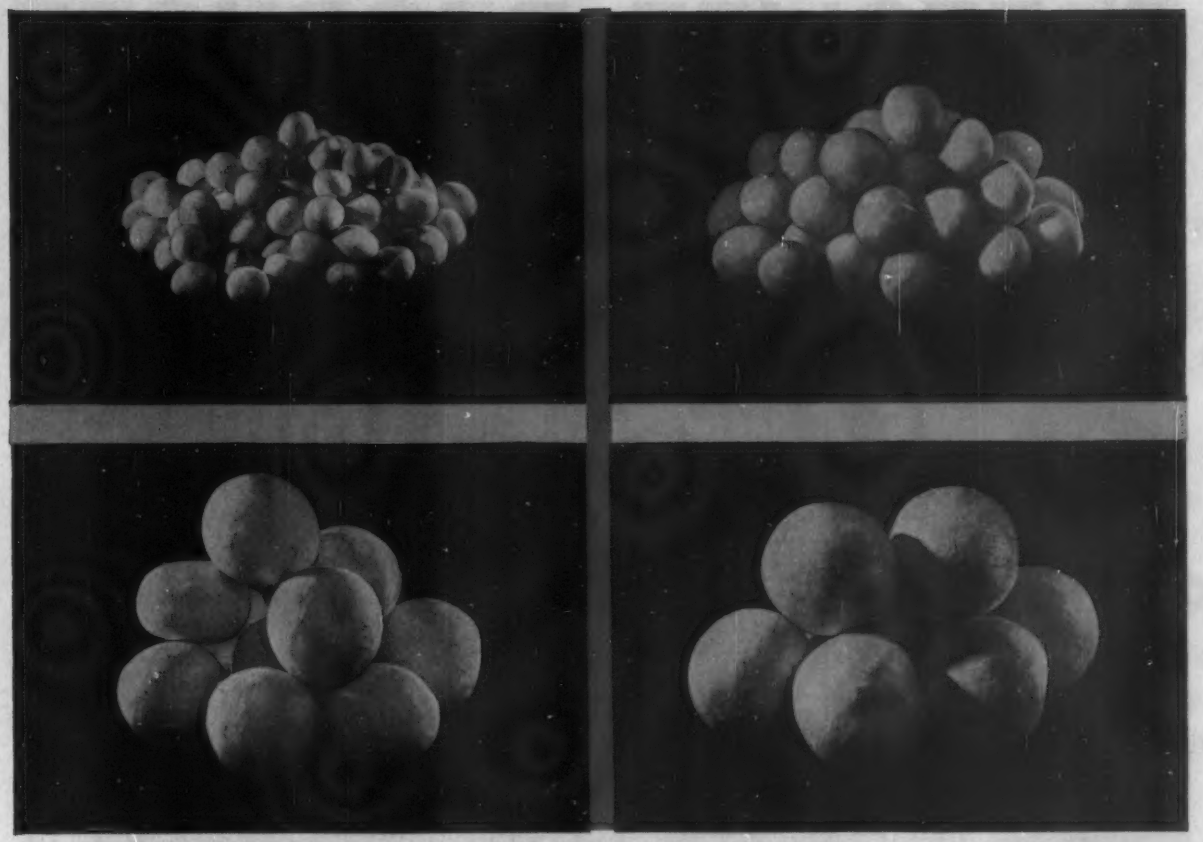
Valves of ductile iron chosen for job. Ductile iron gives Socony Mobil engineers the corrosion resistance of cast iron . . . the superior shock resistance and strength of cast steel at less cost. Ductile iron has the toughness to take the sudden stresses of hydraulic and thermal shock in its stride. All in all, ductile iron offers "no break" performance at a big break in cost.

Next time you specify valves, or other equipment, consider ductile iron. It can reduce the original cost of equipment . . . cut maintenance costs, too. Get complete information from Inco's "Ductile Iron Digest" . . . available to you upon request.

The INTERNATIONAL NICKEL COMPANY, Inc.
67 Wall Street — New York 5, N. Y.

Kennedy Valve Company of Elmira, N. Y., supplied valves of their own 60-45-18 ductile iron specification for Socony Mobil's system.

ductile iron...for iron castings with high strength and toughness



REMMEY INERT SUPPORTS are now available in three plus-90% alumina brands—TA-78, X99A and 90B-6—in sizes from ¼ in. to 2 in. Four popular sizes are shown: ¼, ½, ¾ and 1 in. spheres.

NOW AVAILABLE...REMMEY INERT SUPPORTS IN THREE EXTRA-HIGH-ALUMINA BRANDS

Remmey now offers inert supports for fixed-bed catalytic reforming and dehydrogenation processes in three extra-high-alumina brands and a wide variety of sizes.

Remmey inert supports have proved themselves in some of the world's largest and most modern catalytic refining plants. Produced in diameters from ¼ in. to 2 in., these special refractory spheres feature high purity, chemical inertness, high strength and hardness, complete structural homogeneity and long trouble-free life. They are made in three grades of plus 90% alumina refractories and contain exceedingly low percentages of iron, magnesia, lime, alkalies, titania and other contaminants.

Remmey TA-78 Brand is a general-purpose refractory mixture suitable for most inert support applications. Fired to cone 18 (2732°F), Remmey TA-78 spheres contain 94% alumina, with the balance primarily silica. Average weight is 105 lb. per cu. ft.

Remmey X99A Brand, developed for applications requiring the highest alumina content, contains over 99% Al_2O_3 and is fired to either cone 18 (2732°F) or cone 35 (3245°F). Average weight for cone 18 spheres is 110 lb. per cu. ft.; for cone 35 spheres, 120 lb. per cu. ft.

Remmey 90B-6 Brand meets requirements where weight is a consideration. Containing 90.4% alumina and fired to cone 18, 90B-6 spheres weigh only 78 lb. per cu. ft.

For a wide selection of superior quality inert supports, call on Remmey, leading producers of specialized refractories. Richard C. Remmey Son Co., 700 Hedley Street, Philadelphia 37, Pa. In Canada: A. P. Green Fire Brick Company, Ltd., Toronto 15, Ontario.

MANUFACTURERS OF SPECIALIZED REFRACTORIES . . . REMMEY

A SUBSIDIARY OF A. P. GREEN FIRE BRICK COMPANY

For more data on advertised products, use Readers' Service Cards, last page.

TRETOLITE PRODUCTS

offer you 9 ways to INCREASE and IMPROVE refinery production

1 TRET-O-LITE Demulsifiers

2 TRET-O-LITE Desalting

3 KONTOL Corrosion Inhibitors

4 KONTOL 77 for Products Lines

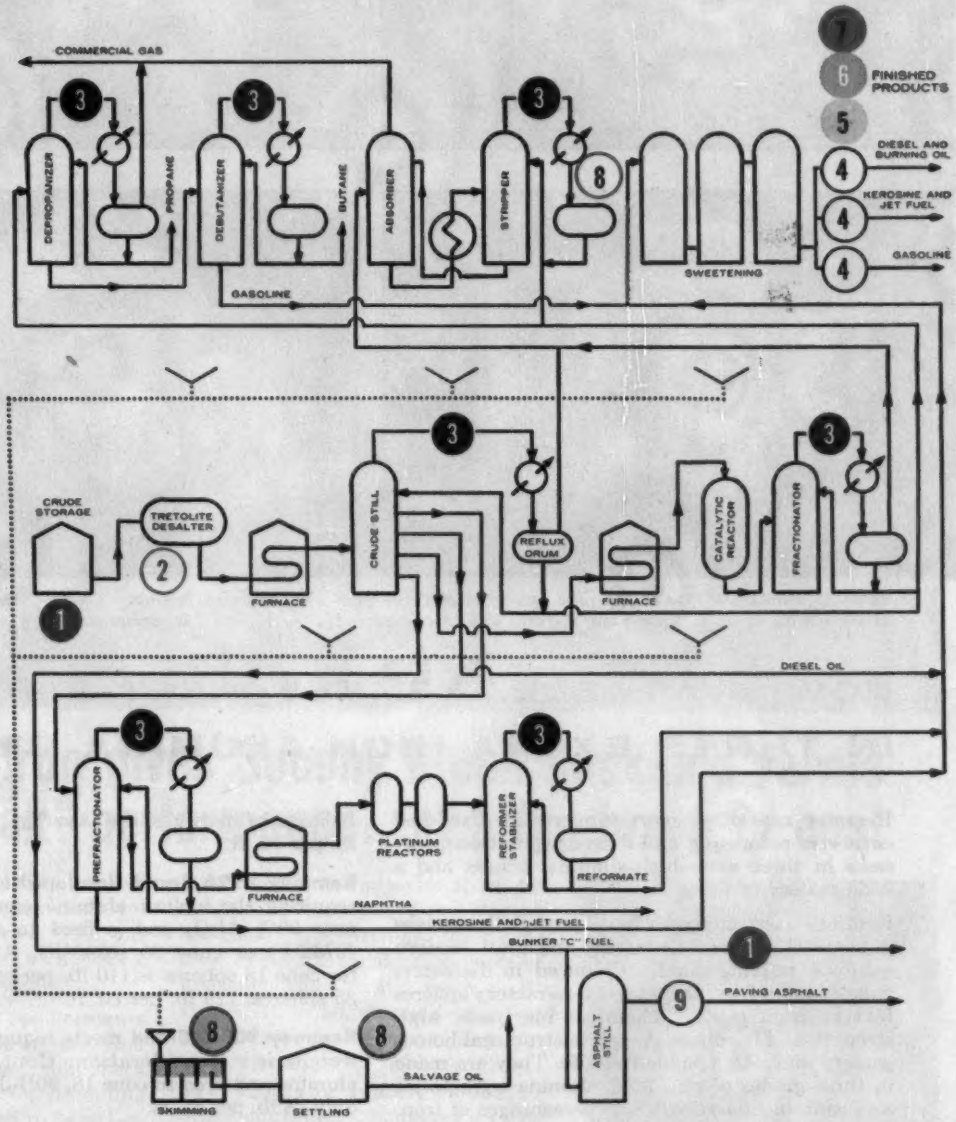
5 KUPLEX Metal Deactivators

6 TOLAD Fuel Oil Additive

7 FEP Fuel Oil Emulsion Preventive

8 TRET-O-LITE Water De-Oilers

9 DEHYDRO Asphalt Additives



TRETOLITE COMPANY

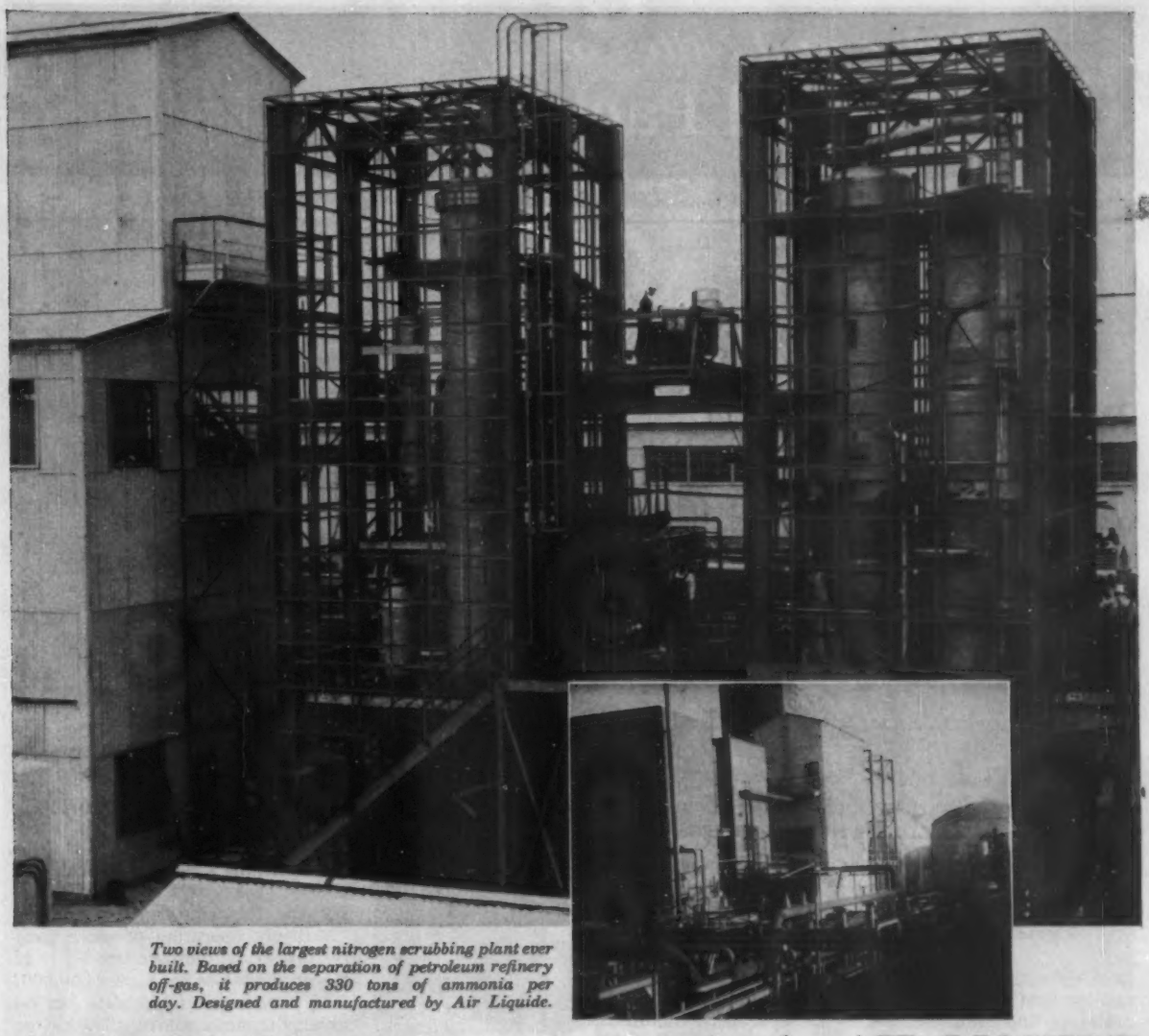
DIVISIONS OF PETROLITE CORPORATION

369 Marshall Avenue, Saint Louis 19, Missouri • 5515 Telegraph Road, Los Angeles 22, California

Chemicals and Services for the Petroleum Industry

DESALTING • CORROSION INHIBITING • DEMULSIFICATION • SCALE PREVENTION • WATER DE-OILING
METAL DEACTIVATION • ADDITIVES

AR-58-2



Two views of the largest nitrogen scrubbing plant ever built. Based on the separation of petroleum refinery off-gas, it produces 330 tons of ammonia per day. Designed and manufactured by Air Liquide.

A *complete* low-temperature service by AIR LIQUIDE

★ *Process Engineering of Complete Plants and of Custom-Designed Equipment*
★ *Technical Consultation for Special Requirements*
★ *Manufacturing of Plants and Equipment*
★ *Plant Erection and Start-Up Supervision*

American Air Liquide places at your disposal the wide experience of research, engineering and manufacturing staffs backed by a half century of "know-how" in the specialized field of low-temperature separation of gaseous mixtures, in North America and throughout the world.

If your present or contemplated operations include the use or production of oxygen, nitrogen, argon, hydrogen, carbon monoxide, methane, ethylene, etc., involving such mixtures as atmospheric air, natural gas, refinery off-gases, coke-oven gases or similar mixtures, our low-temperature technology and plants can meet your requirements.

Some idea of the scope and widespread use of our low-temperature plants is indicated by the fact that in North America alone, every day, more than 2000 tons of oxygen and 2000 tons of ammonia synthesis mixture are being produced in American Air Liquide designed plants.

We shall be pleased to consult with you on the application of Air Liquide processes and equipment to your particular needs.

Write or call us at 405 Lexington Ave., New York 17, N.Y. Telephone: YUkon 6-6544. In Canada: L'Air Liquide, 1111 Beaver Hall Hill, Montreal, Que. Telephone: UNiversity 6-4781.

Here are some of the types of plants we have designed and built:

- *Air Separation — oxygen, nitrogen, etc.*
- *Tonnage Oxygen and Nitrogen (Gas and Liquid)*
- *Rare Gases Recovery*
- *Coke-Oven Gas Separation*
- *Refinery Gas Separation*
- *CO_2 Purification*
- *Methane Purification*
- *Natural Gas Liquefaction*
- *Pure CO_2 Production*
- *Heavy Water — for Atomic Reactors*
- *Hydrogen Liquefaction*
- *Helium Recovery*

AMERICAN
AIR LIQUIDE
ENGINEERING & CONSTRUCTION DIVISION

OLDEST IN EXPERIENCE — NEWEST IN DESIGN

405 LEXINGTON AVE., NEW YORK 17, N.Y.

In Canada: L'AIR LIQUIDE. 1111 Beaver Hall Hill, Montreal, Que.

For more data on advertised products, use Readers' Service Cards, last page.

News and Notes on...

Good Packing Practice

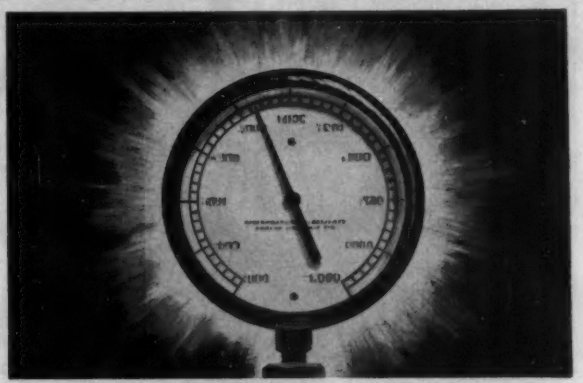
JOHNS-MANVILLE JM PRODUCTS

Maintenance and Design Hints from Johns-Manville Packings and Textiles Dept.

Subject of the month: High Operating Pressures

Problem:

How can today's process industries and equipment meet the requirements to stay "on stream" in the face of increasing burdens placed on packings by higher operating pressures?



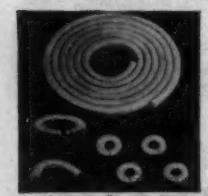
Condition 1

FOR RODS AND PLUNGERS WORKING AT 2,000 TO 3,000 PSI, MOULDED UNEEPAC® RINGS

Wherever reciprocating machinery calls for a minimum of downtime and maximum efficiency in the face of high pressures, Uneepac rings have proved universally dependable. Manufacturer's life tests and applications such as hydraulic presses, pump rods, accumulators, and compressors show Uneepac takes hundreds of thousands of cycles without replacement. Quality materials and carefully engineered design and construction are the key to Uneepac's success in thousands of high-pressure applications. For information on J-M Moulded Packings, write for new, free booklet, PK-126A.

Condition 2

FOR VALVES OPERATING AT PRESSURES TO 5,000 PSI



Tough J-M Chempac® Teflon®-asbestos valve stem packing, Style 2011, combines the heat resistance of asbestos and the corrosion resistance of Teflon. Specify this long-life packing for high-pressure applications to 5,000 psi at temperatures to 500F. In some special cases it has withstood 50,000 psi. You'll find complete details on Johns-Manville's broad line of Chempac Packings in booklet PK-124A. Write for your copy today.

For information on any Johns-Manville Packings and Gaskets, write Johns-Manville, Box 14, New York 16, N. Y. In Canada: Port Credit, Ontario.

Condition 3

SHEET GASKETS FOR PRESSURES TO 1200 PSI (A QUICK RULE OF THUMB)

To determine whether a job calls for a sheet gasket or a metallic gasket, try the following rule of thumb: "Multiply operating pressure (psi) by operating temperature (°F). If the product does not exceed 250,000, J-M Service® Sheet gaskets can be used. Pressures above 1200 psi or temperature above 850°F, usually call for a metallic gasket." J-M Service Sheet No. 60 effectively seals against heat, cold, water, steam, oils, mild acids and caustics.

Condition 4

FOR STANDARD FLANGE APPLICATIONS TO 6,000 PSI

When you run into the problem of extreme pressures and extreme pressure variations, specify Spirotallic® spiral-wound, metal-asbestos Goetze gaskets. Offering high mechanical strength and resilience, Spirotallic Gaskets seat readily under light bolting. Their special interlocking design and stainless steel construction effect and maintain a tight seal in the face of wide temperature and pressure variations. Write for booklet PK-35A.

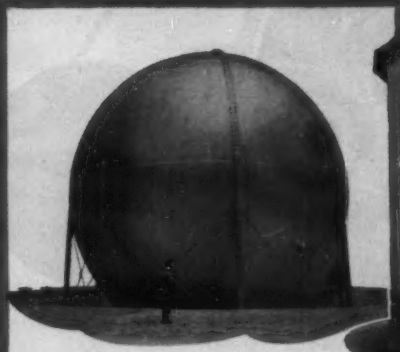
JOHNS-MANVILLE

100 YEARS OF QUALITY PRODUCTS . . . 1858-1958

HAMMOND

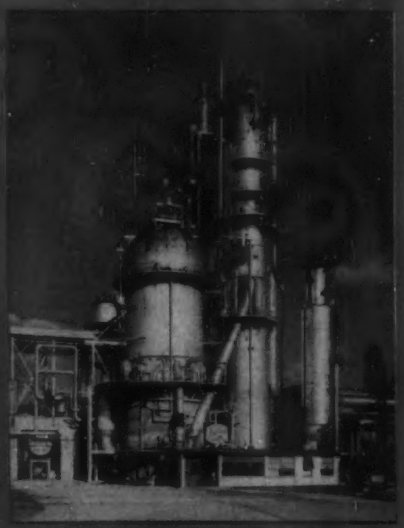
STORAGE TANKS and PLATE FABRICATION

DIALIFT* tank with vapor-saver diaphragm



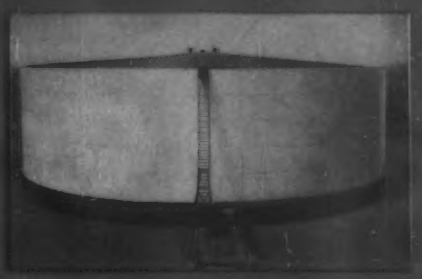
Hammond Spheres

Hammond **TUBESEAL*** and **SPRINGTITE*** Floating Roof Tanks



Process Vessels—Steel • Stainless • Alloys • Cladmetals

Water Storage Tanks



Cone Roof Tanks

The universal acceptance of Hammond-built equipment is the result of more than half a century of experience in the design, fabrication and erection of storage tanks, process vessels and steel plate construction for the petroleum, chemical and allied industries, and for water supply.

HAMMOND IRON WORKS

WARREN and BRISTOL, PA. • PROVO, UTAH • CASPER, WYO. • BIRMINGHAM, ALA.

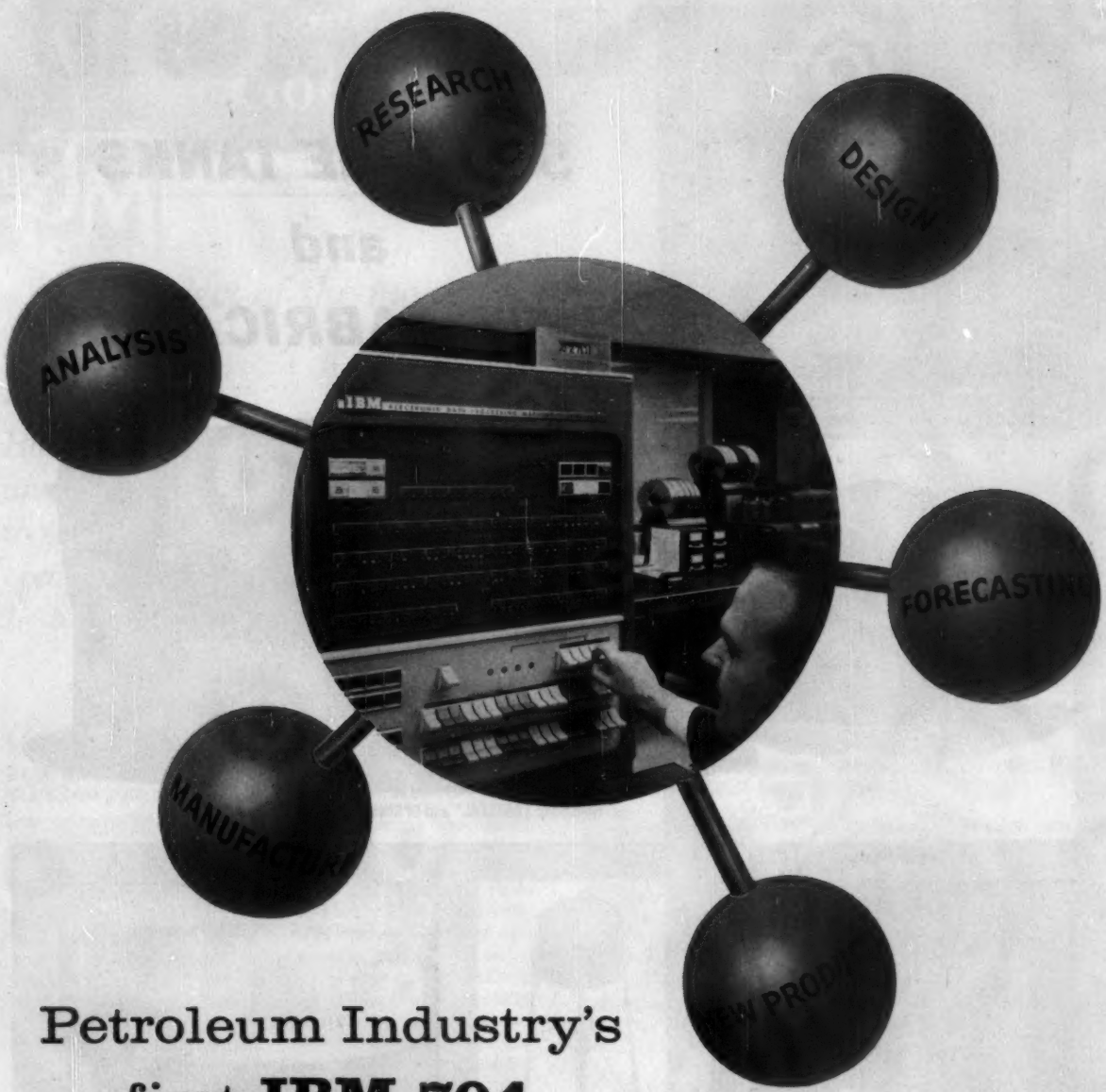
Sales Offices:

NEWARK 2, N. J. • PITTSBURGH, PA. • BOSTON 10, MASS. • BRIDGEPORT, CONN. • CINCINNATI 2, OHIO
CHICAGO 3, ILL. • ARLINGTON, VA. • GREENVILLE, S. C. • LOS ANGELES 57, CALIF. • MEXICO CITY
"TIPSA," BUENOS AIRES • PORT-AU-PRINCE, HAITI • LIMA, PERU

Licensees: CALIFORNIA, CANADA, ENGLAND, BELGIUM, GERMANY, ITALY, FRANCE, AUSTRALIA, JAPAN, THE NETHERLANDS, COLOMBIA, BRAZIL

*patented

HAMONDTANK



Petroleum Industry's first **IBM 704**

–installed by Standard Oil of California

Just a few months ago, the Standard Oil Company of California put the petroleum industry's *first* IBM 704 to work.

Today, this electronic computer is active in all phases of SOCAL's operation. From pure research to production and marketing, the 704, which performs 40,000 mathematical operations every second, is solving problems that would otherwise be impossible to attempt.

For the story of how the IBM 704 can help your company, call your local IBM Representative, or write: PETROLEUM DEPARTMENT A58-a, IBM Corporation, 590 Madison Ave., New York 22, New York.

IBM DATA PROCESSING

EXPLORATION • PRODUCTION • REFINING • TRANSPORTATION • MARKETING

For more data on advertised products, use Readers' Service Cards, last page.

POWELL

world's largest family of valves

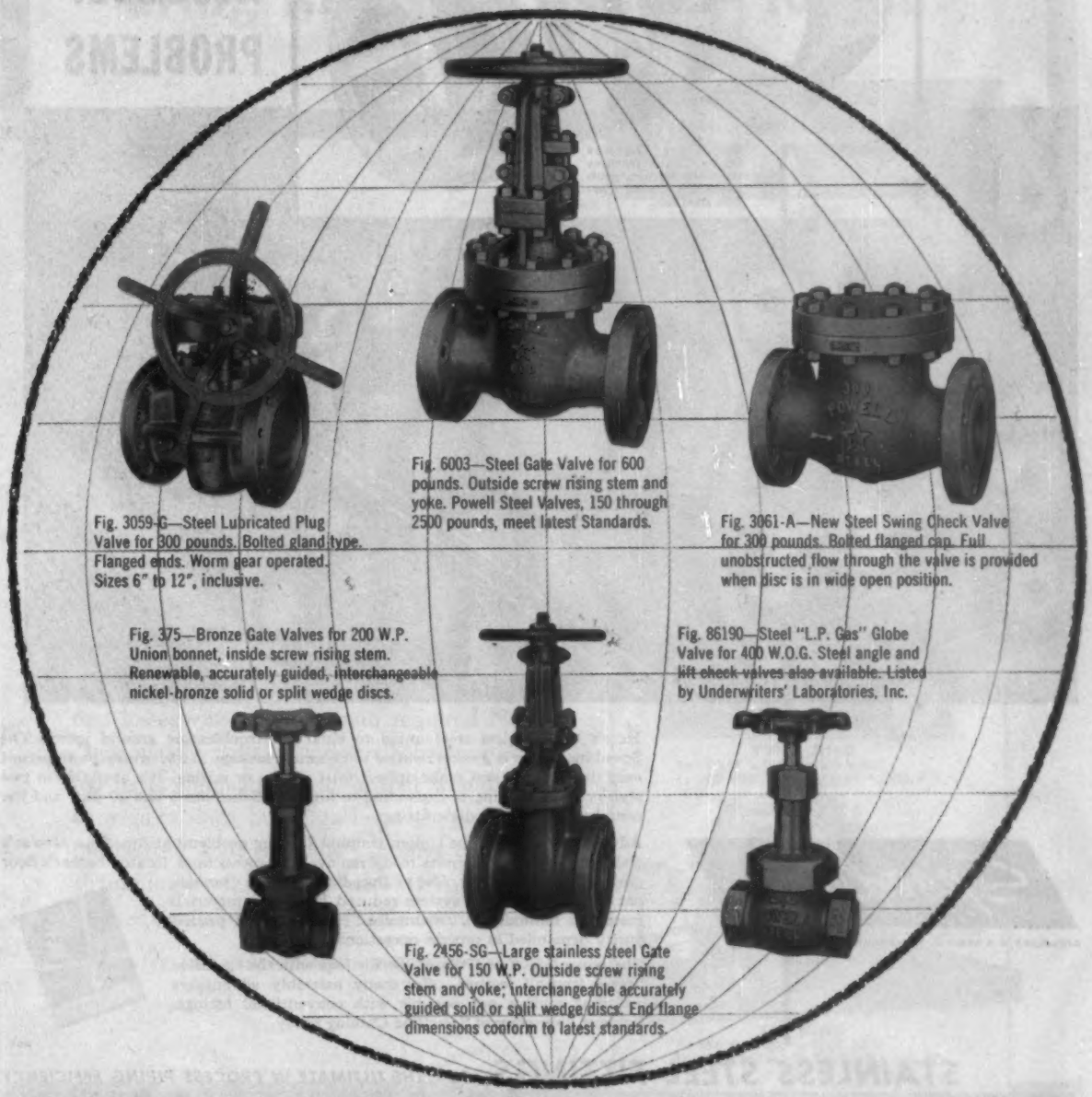


Fig. 3059-G—Steel Lubricated Plug Valve for 300 pounds. Bolted gland type. Flanged ends. Worm gear operated. Sizes 6" to 12", inclusive.

Fig. 6003—Steel Gate Valve for 600 pounds. Outside screw rising stem and yoke. Powell Steel Valves, 150 through 2500 pounds, meet latest Standards.

Fig. 3061-A—New Steel Swing Check Valve for 300 pounds. Bolted flanged cap. Full unobstructed flow through the valve is provided when disc is in wide open position.

Fig. 375—Bronze Gate Valves for 200 W.P. Union bonnet, inside screw rising stem. Renewable, accurately guided, interchangeable nickel-bronze solid or split wedge discs.

Fig. 86190—Steel "L.P. Gas" Globe Valve for 400 W.O.G. Steel angle and lift check valves also available. Listed by Underwriters' Laboratories, Inc.

Fig. 2456-SG—Large stainless steel Gate Valve for 150 W.P. Outside screw rising stem and yoke; interchangeable accurately guided solid or split wedge discs. End flange dimensions conform to latest standards.

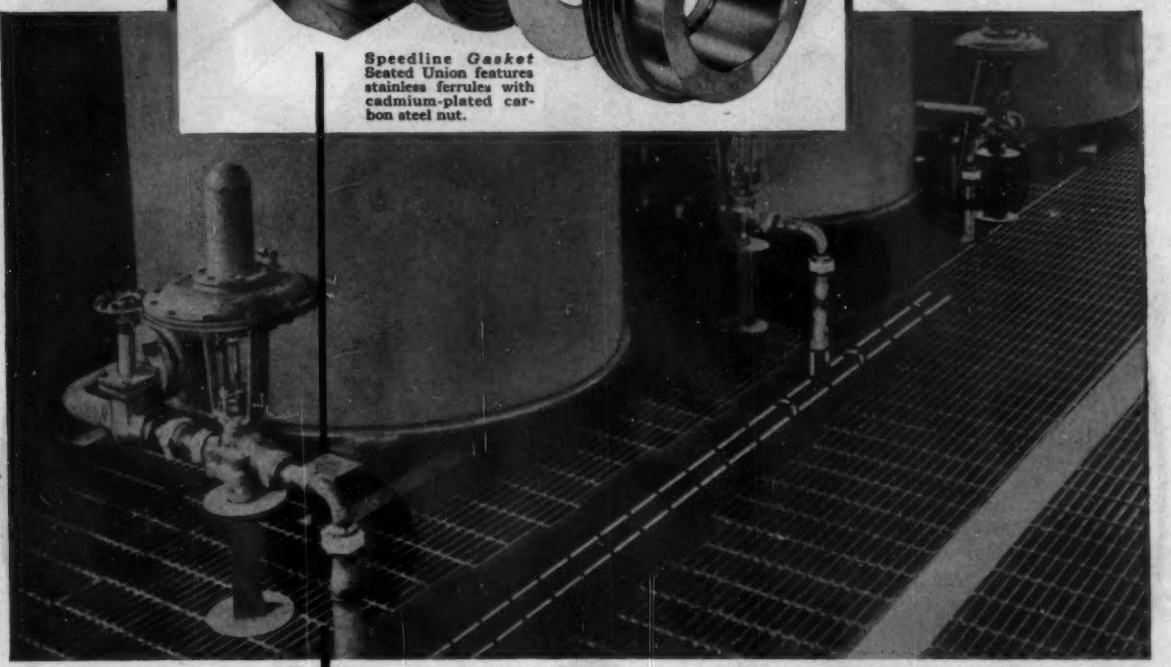
A solution for every kind of flow control problem is as near as your local Powell distributor. Powell valves are designed and engineered in the largest variety of metals and alloys, to handle any medium, every flow control requirement. There are Powell distributors in all principal cities. Or, if yours is a special engineering problem, write to:

THE WM. POWELL COMPANY • *Dependable Valves Since 1846* • **Cincinnati 22, Ohio**

For more data on advertised products, use Readers' Service Cards, last page.

SPEEDLINE FITTINGS SOLVE LEAKAGE AND ASSEMBLY PROBLEMS

Speedline *Gasket* Seated Union features stainless ferrules with cadmium-plated carbon steel nut.



Here's the stainless steel union to eliminate troublesome ground joints. The Speedline Union is *gasket seated* to eliminate leakage . . . *bi-metallic* to permit easy disassembly and make-up *without* galling or seizing. It's available in two styles . . . for welding or expanding to low cost Schedules 5 and 10 pipe and the complete line of Speedline fittings.

Advantages of Speedline Unions simplified piping problems at American Alcolac's Baltimore plant . . . permits ready removal of process lines located beneath floor grating when necessary. Use of Speedline Fittings throughout the plant's piping system reduced labor and materials costs to a minimum . . . maintained high degree of process purity demanded in process operations.

The *complete line* of Speedline Fittings with the exclusive "extra length" feature, offer many assembly advantages and cost savings not possible with conventional fittings. Request your copy of Speedline Catalog today.

Speedline

SPEEDLINE IS A REG.T.M. OF HORACE T. POTTS COMPANY

905

STAINLESS STEEL FITTINGS—FOR THE ULTIMATE IN PROCESS PIPING EFFICIENCY

Speedline Distributors are Located in Principal Cities

Manufactured by **HORACE T. POTTS COMPANY** • 502 E. Erie Avenue • Philadelphia 34, Penna.

Pacific Process Pump **EXTRAS** bring **EXTRA PROFITS** to you!

MAXIMUM PARTS INTERCHANGEABILITY is an extra feature in PACIFIC PROCESS PUMPS

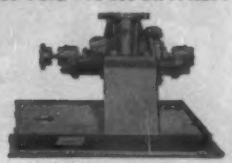
EXTRA CORROSION ALLOWANCE—All Pacific Process pumps are custom-built with case casting thickness in excess of actual pressure-temperature requirements. This provides a liberal allowance for corrosion-erosion and a high safety factor.

EXTRA HEAVY CONSTRUCTION—Pacific process pumps are engineered to combine the strength necessary for continuous heavy duty service with design simplicity and accessibility for low maintenance cost. All parts in contact with pumped liquid may be fabricated from any commercially available ferrous or non-ferrous metal.

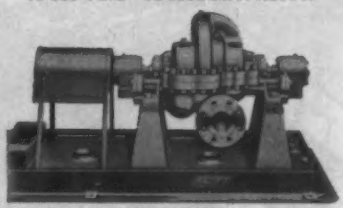
EXTRA LONG LIFE—Guided inlet flow reduces friction losses—insures minimum required NPSH. Dynamically, radially, and axially balanced moving parts eliminate vibration that would cause damage to rings, bushings, bearings, packing or mechanical shaft seals and excessive radial and thrust loads on bearings. Result—greatly increased availability for profitable operation.

Write for bulletins—please specify pump type.

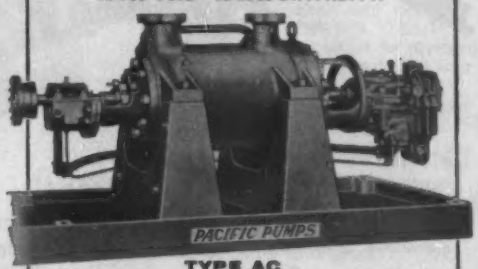
TYPE SVC
To 850°F.—25 to 3200 GPM
To 600 PSIG—To 650 DIFF. HD. FT.



TYPE HVC
To 850°F.—600 to 4500 GPM
To 600 PSIG—To 1000 DIFF. HD. FT.



TYPE RHC
To 500°F.—50 to 3000 GPM
To 700 PSIG—To 1300 DIFF. HD. FT.



TYPE AC
To 850°F.—100 to 2500 GPM
To 1000 PSIG—To 2600 DIFF. HD. FT.

PACIFIC PUMPS INC
A Division of Dresser Industries, Inc.
HUNTINGTON PARK, CALIFORNIA

PACIFIC

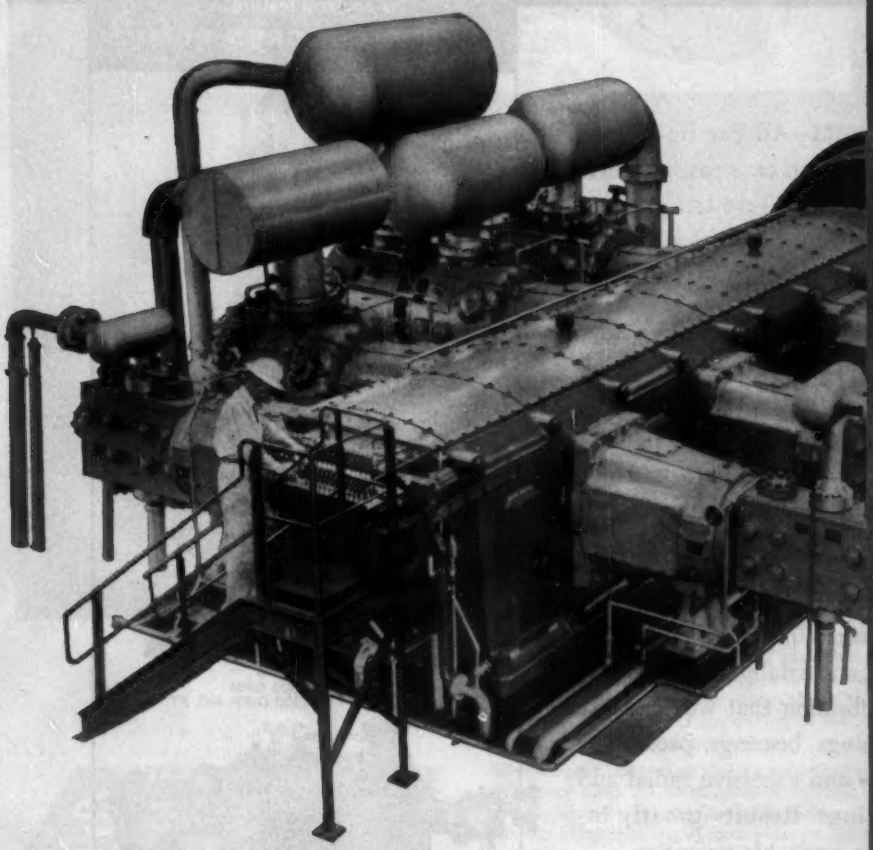
Offices in All Principal Cities

6P-19

For more data on advertised products, use Readers' Service Cards, last page.

America's most powerful compressor

THE 10,000 HP COOPER-BESSEMER LM



Designed for the continuous compressing of large volume gas or air . . . in petrochemical, chemical, refinery and industrial operations . . . this 10,000 hp Cooper-Bessemer LM compressor not only delivers efficiency, economy and availability, but occupies no more space than other units of half the horsepower.

Cooper/Bessemer

GENERAL OFFICES: MOUNT VERNON, OHIO

ENGINES: GAS - DIESEL - GAS-DIESEL
COMPRESSORS: RECIPROCATING AND CENTRIFUGAL
ENGINE OR MOTOR DRIVEN

BRANCH OFFICES: Grove City • New York • Chicago • Washington • San Francisco • Los Angeles • Houston • Dallas • Odessa • Minneapolis • New Orleans • Shreveport

SUBSIDIARIES: COOPER-BESSEMER OF CANADA, LTD.... Edmonton • Calgary • Toronto • Halifax
COOPER-BESSEMER INTERNATIONAL CORPORATION . . . New York • Caracas • Mexico City

Proved by thousands of operational hours

the basic LM design offers you the very latest in design and engineering development. The nearest Cooper-Bessemer office will gladly furnish complete information.

THE LM COMPRESSOR OFFERS YOU THESE TEN IMPORTANT ADVANTAGES:

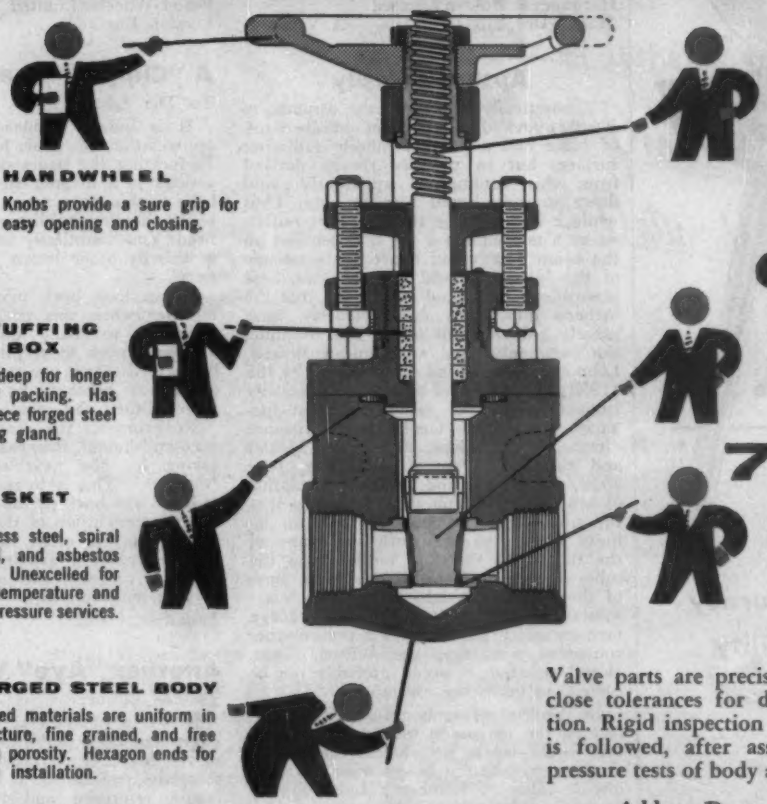
- natural force balance design for vibration-free operation
- lowest investment per horsepower
- greatest power-to-space ratio
- low installation cost
- minimum maintenance requirements
- main frame of high strength Meehanite Metal
- rod load rating, 125,000 psi
- pistons can be removed without disturbing compressor piping
- extreme accessibility
- greatest availability for multi-stage, multi-service requirements

150-800 POUNDS SERVICE
2000 POUNDS COLD, W.O.G.
SIZES ¼" THRU 2"

A NEW Vogt

ROUND BOLTED BONNET, BOLTED GLAND
FORGED STEEL GATE VALVE

with 7 superior features



1 HANDWHEEL
Knobs provide a sure grip for easy opening and closing.

2 STUFFING BOX
Extra deep for longer life of packing. Has one-piece forged steel packing gland.

3 GASKET
Stainless steel, spiral wound, and asbestos filled. Unexcelled for high temperature and high pressure services.

4 FORGED STEEL BODY
Forged materials are uniform in structure, fine grained, and free from porosity. Hexagon ends for easy installation.

5 STEM
13% Chrome stainless steel. A special high melting point alloy yoke nut assures prolonged wear resistance.

6 WEDGE
13% Chrome stainless steel of approximately 500 Brinell for longer wear.

7 SEATS
13% Chrome stainless steel, hard faced with *HAYNES STELLITE or equivalent for stubborn resistance to seat wear.

Valve parts are precision machined to close tolerances for drop tight operation. Rigid inspection of finished parts is followed, after assembly, by final pressure tests of body and seats.

Address Dept. 24A-FPR.

*Trade mark of Union Carbide Chemicals Co.

Vogt

GENERAL GP PURPOSE

Vogt FOR BETTER VALVES

HENRY VOGT MACHINE COMPANY, Louisville, Ky.

SALES OFFICES: New York, Chicago, Cleveland, Dallas, Camden, N. J., St. Louis, Charleston, W. Va., Cincinnati.

DROP FORGED STEEL

VALVES

For more data on advertised products, use Readers' Service Cards, last page.

PALMER
presents
an outstanding
improvement in
DIAL THERMOMETERS

external
calibration
Full 3½" Dial Face

- No Sector
- No Pinion
- No Linkage
- Constant Accuracy
- Easy Readability

WRITE FOR BULLETIN 350

PALMER
THERMOMETERS, INC.
Norwood Ave., Cincinnati 12, Ohio
Mfrs. of Industrial Laboratory Recording and Dial Thermometers

The Mail Box . . .

Asks a Question

To The Editor:

With reference to the article on "Calculating Heater Tube Temperatures" by A. Doll-Steinberg (December PETROLEUM REFINER, P165) I note that the author has assumed that the intensity of direct radiation reaching the tube does not vary with the direction from which it comes. As I understand it, however, the heat radiated by a non-luminous gas is dependent upon the "length" of the radiant beam, i.e. upon the depth of gas from which radiation is received. If this is so, then the intensity of radiation received by any part of the surface of a tube arranged close to a furnace wall will presumably depend upon the geometry of the furnace. I should be glad to have the author's comments on how this variation might affect the conclusions which he draws, especially since at the limit of permissible metal temperatures small inaccuracies in calculation are often significant.

Hardman & Holden Limited
Manchester, England — A. V. Bailey

Author's Reply

Theoretically of course the assumption is strictly valid only for an infinite bank of tubes and a parallel infinite radiating surface, but in practice results derived from this assumption apparently hold down to quite small furnace sizes. Thus while it is quite true that the heat radiated by a non-luminous gas is dependent on the beam length and hence the geometry of the furnace should influence the heat absorption, it is found in practice that the furnace dimensions and geometry have usually only a small effect. For example, the commonly used equation of Wilson, Lobo and Hottel (Ind. Eng. Chem. 24,486 (1932)) which was obtained empirically from the study of twelve different furnaces, contains no terms for the furnace dimensions or shape. Similarly, Mekler and Fairall (PETROLEUM REFINER, June 1952) base a method for the calculation of heat absorption on the assumption that the products of combustion form an infinite surface parallel with the plane of the tubes, i.e. that the radiation to the tubes is uniform from all directions. Both of these methods yield results which are substantiated in practice; however for a furnace which did not give a performance consistent with say, the Wilson, Lobo, Hottel equation it would probably not be correct to make the assumption.

In the case of such a furnace, the effect on the maximum tube wall temperature would depend on whether the oblique or the perpendicular beams were the more intense. Due to Lambert's Law, oblique beams produce a larger effect on the sides of the tube than on the front. Hence, an increase in the intensity of these beams at constant average radiant rate would lead to a smaller maximum flux and hence to a smaller maximum temperature. The converse would follow from a decrease in the intensity of these beams.

I believe the reason that the assumption of uniform radiant intensity in all directions provides in the majority of cases a sufficiently close approximation to the truth, stems from the fact that the furnace cavity is not a constant temperature enclosure. In the usual furnace design the plane of the burner axes is parallel with the plane of the tube-banks and conditions will approximate a central, parallel-sided, high temperature zone flanked on either side by zones of cooler gas. The radiation emitted by the central zone will be partially absorbed in the cooler zones, and an oblique ray originating in the central zone with a longer beam length will be subjected to a longer path through the cooler zones.

I may add that both Hottel (Trans. ASME, 53, 265 (1931)) and Mekler and Fairall (loc. cit.) obtain for the radiant heat variation round the circumference of a tube the same results by graphical methods as I have derived analytically in the first part of my article. My main purpose was to go further and to allow for the effect of heat conduction in the tube wall in obtaining the maximum temperature. It is the analytical solution of the part of the problem previously solved graphically that makes this step possible.

Foster-Wheeler Limited
London, England — A. Doll-Steinberg

A "Clipper" Speaks

To The Editor:

It is indeed a pleasure to offer my appreciation of your March 1958 issue. Perforating the pages of all your leading articles is a distinct step forward, and I believe this gives you the distinction of being the first publisher to recognize this need. You doubtlessly will be made aware of this by other letters from other "clippers."

I can look back many years and remember when this perforating idea was suggested to many publications. I can also remember the replies which invariably agreed that it was not practical for one reason or another. So you really have accomplished the impossible.

Realizing all the years needed for this accomplishment, it perhaps is time to start asking for the next step to help the "clippers." This is to not start a new article on the back of the page, which carries the conclusion of the previous article.

It is also in order to compliment you on the splendid articles you have been carrying recently and on the excellency of your magazine in general.

Pasadena, Calif. — F. L. Kallam

Another "Aye" Vote

To The Editor:

It was a pleasant surprise to find the pages had been perforated on the articles in the March PETROLEUM REFINER. I almost always tear out at least one item for future reference and frequently get a rather ragged edge. The perforation of the pages enables one to obtain a straight edge quickly and I hope you continue to do this.

Bartlesville, Okla. — N. A. Stumpe, Jr.

None in Norway

To The Editor:

On page 184 of your February issue you mention that British Petroleum is going to build a 40,000-barrel-a-day refinery on the east bank of the Oslo Fjord. For your information I wish to inform you

AMOCO CHEMICALS—
A NEW RESOURCE

New to the Amoco Additives line

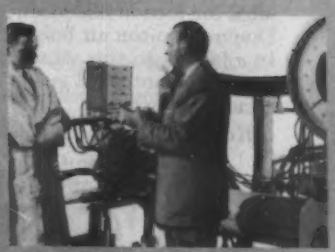
V. I. Improver
Metal Deactivator
3 Antioxidants

V. I. Improver. Polyisobutylene-type viscosity index improver especially suited for use in multigraded motor oils. Amoco V. I. Improver can help you blend—*economically*—oils that give users: (1) better oil mileage, (2) less octane-requirement increase, (3) better gasoline mileage, (4) easier engine starting in cold weather.

V. I. Improver evaluation data—some of the most extensive in the automotive and petroleum industries—are available to you from Amoco petroleum additive sales engineers.

Metal Deactivator and 3 Antioxidants. Four other new Amoco Additives are now available. Their use will eliminate the problem of hydrocarbon oxidation and gum formation in gasolines and other products. The metal deactivator is disalicylidene propylenediamine. The antioxidants are: (1) an aminophenol, (2) a phenylenediamine, (3) an alkylated phenol (DBPC).

More information about these new Amoco Additives is available. Amoco sales engineers with special experience in the use of petroleum additives will bring it to you. Your request for data will receive immediate attention.



AMOCO CHEMICALS

AMOCO CHEMICALS CORPORATION

910 South Michigan Ave., Chicago 80, Illinois

A swift, safe lift

with non-sparking air hoist

For lifting power that's safe from fire and explosion hazards, use Gardner-Denver air hoists. Non-sparking axial-piston air motor makes these hoists ideal for jobs in chemical, gaseous or dusty atmospheres. Here, a Gardner-Denver two-ton air hoist lifts a mixing vat in a paint manufacturing plant. In addition to this vital safety feature, Gardner-Denver air hoists provide an easily controlled speed for a swift, steady lift—with gentle starts and accurate stops.

Keller air hoists in sizes from 150 lb. to 2 tons. Write for Bulletin 80.

ENGINEERING FORESIGHT—PROVED ON THE JOB
IN GENERAL INDUSTRY, CONSTRUCTION, PETROLEUM AND MINING

GARDNER DENVER

Gardner-Denver Company, Quincy, Illinois

The Mail Box . . .

that the Company has no such plans to build any refinery in Norway.

W. C. Connel,
Information Officer
British Petroleum Co., New York

Editor's Note—We are glad to publish this statement. The erroneous information was received from what was thought to be a reliable source.

Strong Vote "For"

To The Editor:

Just wanted to drop you a line to register my enthusiasm for the way you are fixing the pages of PETROLEUM REFINER so that articles can be torn out easily and neatly. I have always been a great tearer-out of articles as the only practical solution to a problem which would otherwise have long since filled both the house and the office with magazines.

I realize that this improvement in the REFINER probably puts you to some added trouble and added expense, and I want to register one strong vote in favor of continuing it.

Marshall Sittig
President, Managing Director
American Lithium Institute,
Princeton, N. J.

Service to Writers

To The Editor:

Last year you were kind enough to supply us with copies of your Author's Handbook for those attending our Technical Writers' Institute. These proved to be very informative and instructive for those attending.

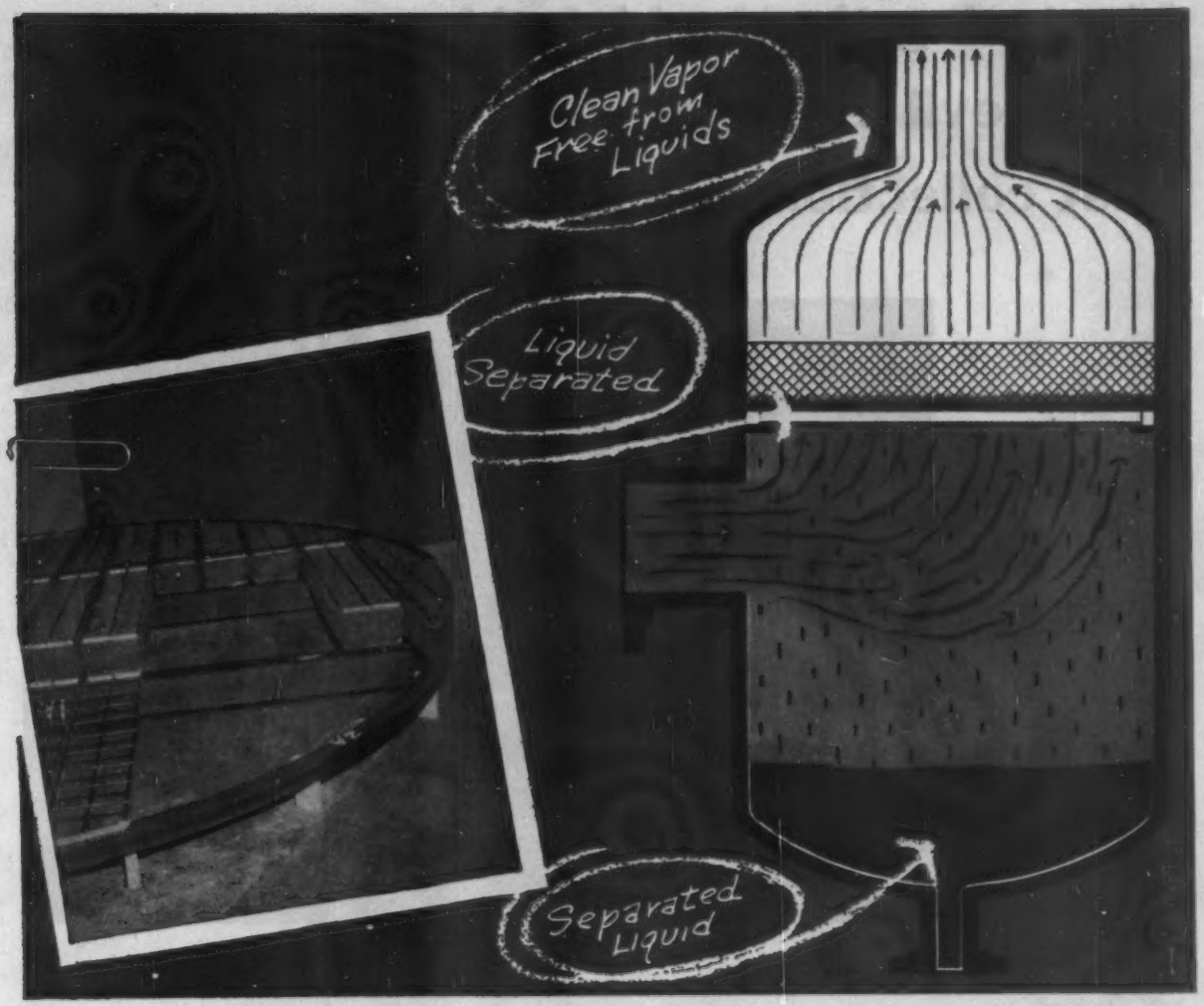
Would you be able to supply us with 150 copies of the same publication for the 1958 Writers' Institute which is scheduled June 9-13? As you can see from the list of companies represented, the publication would have wide distribution.

Jay R. Gould, Director
Rensselaer Polytechnic Institute,
Troy, N. Y.

Editor's Note—Sure thing. Our third printing of this helpful booklet should be ready in ample time for this purpose.

PETROLEUM REFINER welcomes letters of comment dealing with timely topics pertinent to the industry.

For more data on advertised products, use Readers' Service Cards, last page.



How to IMPROVE Process Vessel PERFORMANCE

By effecting clean separation of liquid from vapor Yorkmesh Demisters improve process vessel performance.

In **distillation equipment** liquid entrainment is controlled, giving better quality overhead products even at increased thruput rates.

In refinery **vacuum towers,** higher quality gas oil means higher conversion rates to gasoline in the cat cracker.

In **absorbers,** loss of absorbing liquid is prevented.

In **separator vessels** and **knock-out drums** greater liquid recovery results.

In compressor **suction drums,** complete liquid separation decreases compressor maintenance.

In **evaporators,** by controlling liquid carry-over product loss is avoided, and high purity condensate is suitable for boiler feedwater or process use.

In **steam drums** the result is clean, dry steam.

In **vent stacks** Yorkmesh Demisters contribute to the solution of air pollution problems.

Write for Bulletin 17 and a complete list of the many case histories available from our technical library.

YORK

OTTO H. YORK COMPANY, INC.
6 Central Avenue, West Orange, N. J.

Specialists in FLUIDS SEPARATION / ENGINEERS and MANUFACTURERS

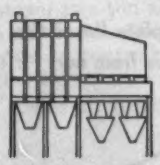
For more data on advertised products, use Readers' Service Cards, last page.

Mastering the double-eddy dust devil leads to extra dust collection efficiency!

DUST IN THIS PART OF THE DOUBLE EDDY WHIRLS UP IN ALL CYCLONES...
BUT BUELL'S EXCLUSIVE "SHAVE-OFF" TRAPS IT...
HARNESSES THE "DUST DEVIL" FOR EXTRA EFFICIENCY!

BUELL CYCLONES

"SF" ELECTRIC PRECIPITATORS



PRECIPITATOR-CYCLONE COMBINATIONS

Only Buell Cyclones have the "Shave-off" that removes the fines carried in the double-eddy currents, minimizes reentrainment, assures measurably higher dust collection efficiency! Other exclusive extra-efficiency features include *large-diameter* design that eliminates bridging and clogging, proper proportioning for maximum dust separation from the gas stream, extra-heavy-gauge, wear-resistant construction, Buell-designed manifolding that minimizes draft loss, minimizes scouring and eddying. For more information send for a copy of the booklet, "The Exclusive Buell Cyclone." Dept. 21-E, Buell Engineering Company, Inc., 123 William Street, New York 38, N. Y.

buell®

Experts at delivering Extra Efficiency in **DUST COLLECTION SYSTEMS**

A Quick Look at the Industry THIS MONTH

Sniping Continues At Voluntary Import Plan . . . It's still open season on the voluntary imports plan, and critics are taking shots from all directions. Rep. Edmondson (D-Okla.) charges the plan is like "giving the cell key to a lawbreaker with the assumption he will lock himself in and be content to stay there." Chairman of House subcommittee on mines and mining Rep. Rogers (D-Texas) blasts what he calls "the greed on the part of certain people who have controls of the fuels that can be obtained from foreign sources." Even labor got into the act as the vice president of one powerful OCAW local claimed imports are forcing American labor to compete with that of foreign countries, and as a result many union men men are being laid off.

Meanwhile, Rep. Ikard's (D-Texas) bill took the lead as the basis for mandatory import controls as many domestic oil interests and even coal-state legislators lined up solidly behind it. Bill proposes to trim imports to the 1954 ratio and then require each importer to bid for license to bring foreign crude into the country. Highest bidders get licenses.

Imports Administrator Carson, viewing the situation, commented that mandatory import controls would saddle the oil industry with even more federal control than exists now. "The good which would come from this action would undoubtedly be buried with the bones of the petroleum industry, while the evil would live afterward," he warned calmly.

What Will Come From All The Shouting? . . . In spite of the impressive support in Congress for mandatory controls of oil imports, chances are the Ikard bill won't pass this year. Since oil is only one part of the reciprocal trade issue, any mandatory controls would bring demands by other industries claiming to be hit hard by low-cost foreign imports.

In all probability, legislative controls will be imposed only if the voluntary system breaks down completely.

Canada Having Import Troubles, Too . . . Canadians are also focusing their attention on the question of imports. Opinion is that if Canadian oil is refused access to U. S. markets for a considerable period, government might decide on action resulting in the barred Canadian crude being substituted for that which is presently imported from the U. S.

Sun Oil Leery of Repercussions . . . Shortly after the Military Supply Agency added a new clause to its bid invitations requiring bidders to state compliance with the revised imports, there was trouble. Sun Oil refused to sign the compliance on basis that addition to bid form is "contrary to law" and "invalid." All other bidders signed statement—including Tidewater and Eastern States.

In the back of Sun's mind is a gnawing fear that a new administration might take advantage of current imports handling to file antitrust charges against those who cooperate. O'Mahoney committee blasts against Middle East Emergency Committee give ample substance to fears.

Latest Octane Postings . . . Average octane ratings of gasoline have held steady for the last two months according to Ethyl survey. Premiums average 98.5 F-1 while regulars are holding at 91.1 F-1.

Ethyl spokesmen claim future rate of octane climb will be about 0.4 numbers per

year instead of more than one whole number as in the past. Even so, another company, Esso, claims today's octanes yield 21 percent more energy for transportation with only 6 percent more expenditure of production effort.

Panning the Washington Scene . . . Planned congressional investigation of gasoline surpluses probably won't materialize this year . . . **Government has abolished** ODM and will switch duties, including oil policy matters, to new organization not yet created . . . **State Department has advised Congress** that offshore buying of petroleum products for offshore use is not affected by the "Buy American" amendment.

New Treating Method to Cut Costs . . . CRC's new method for treating catalyst beads is expected to save from $135,000 to $250,000 per year on a 15,000-bpd cat cracker. Method is based on improving the cohesion of catalyst beads, thus reducing amount of fine particles circulating. Initial process installation requires no shutdown and costs $5,000. Operating costs run about $5 a day for materials per hundred tons of catalyst. Process, which is already being used by eight plants, is suited for all liquid feed cat cracking units using extruded clay or bead catalyst.

Just How Big Is Little? . . . Government has clarified definition of "small business" for procurements. Among other requirements, business cannot be larger than 1,000 persons nor have a processing capacity of more than 30,000 bpd.

New Separation Techniques . . . More is being done to perfect easier method of making those difficult hydrocarbon separations. One method reported is to tailor-make activated carbon to achieve selective adsorption of certain materials. American Oil offers another way—membrane permeation (more information on Page 214).

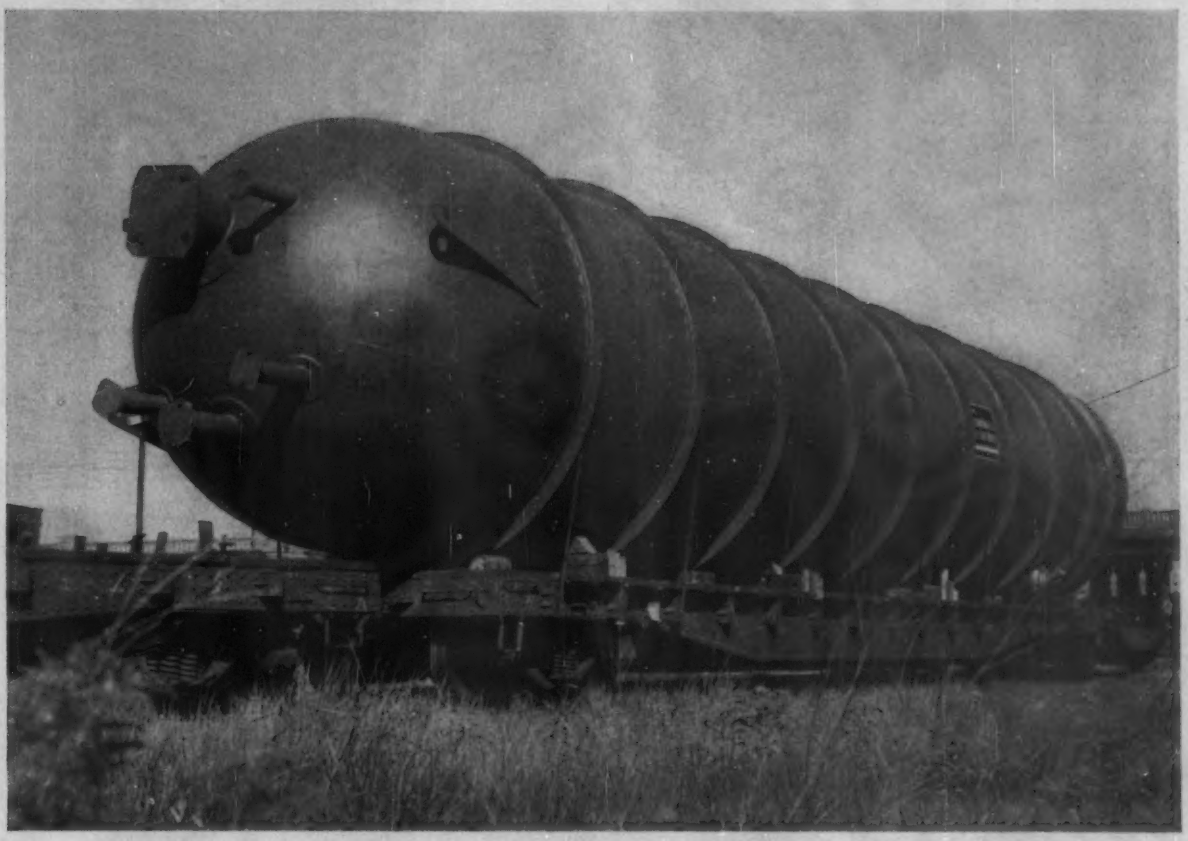
A Quick Look Around The Country . . . After recent fire and explosion, Ben Franklin's Ardmore, Okla., refinery is back on stream. Leak in propane loading line was cited as cause of explosion which destroyed two 5,000-barrel loading tanks and slightly damaged warehouse and lab . . . **Humble has discontinued operation** of its Baytown, Texas, butadine unit for "an indefinite period" . . . **Ethyl will lay off** 449 more workers—this time at Baton Rouge . . . **Fire swept through** Esso Standard's Newport News, Va., marine terminal and in two days destroyed 11 of the 21 storage tanks.

Oil Refining Saves The Day . . . With steel production down and coal byproducts off, the petrochemical industry saved the day for processors using B-T-X aromatics. Even newer entries in the petrochemical field faired quite well as some industries realized that petrochemicals offer superior quality on a reliable delivery schedule.

And Here's More Good Petrochemical News . . . Whole new petrochemical outlet may be in the making if tests are successful with Imperial Oil's new rubberized collapsible storage tank designed for cold weather use. Built to withstand temperatures to —64 F., the 5,100-gallon tank is made of neoprene-coated nylon. If military becomes interested, market will really blossom.

In other circles, Du Pont has officially endorsed nylon over rayon for vehicle tires. After extensive tests, nylon tires proved superior in durability, and in heat, moisture and bruise resistance. Unofficial expectations put nylon only on all cars by 1965. Next big question: When will polyesters start making a bid for a chunk of this big market?

MTB Fabrication Fact Sheet



Giant Vacuum Bottle for Catalyst Storage

This vessel, recently shipped to a well-known Midwest refiner, was fabricated from ASTM A-285 Grade C steel. It measures 13′ x 70′ long and weighs 35 tons. The shell, designed for a full vacuum, is reinforced with external Tee bars, while the head is hemispherically shaped and the bottom toriconically shaped—thus reducing the over-all thickness of the vessel.

In addition to quality fabrication, on-time delivery of this job was a major consideration and Missouri Boiler kept its promise to help this contractor meet a vital construction schedule.

If you would like to solve your delivery and scheduling problems, add Missouri Boiler to your bidders' list for dependable quotations on custom fabricated pressure vessels and storage tanks.

(steel and alloy plate—3/16" to 1-1/4"
stress relieved X-rayed)

MISSOURI BOILER AND TANK COMPANY

Formerly Missouri Boiler and Sheet Iron Works

2216 Papin Street **St. Louis, Missouri**

For more data on advertised products, use Readers' Service Cards, last page.

Planning ahead can save $20,000 on fluid mixing

An idea from your LIGHTNIN MIXER representative's briefcase

This engineer is listening to an idea that's going to save his company $20,000 on fluid mixing.

He's working on a process that will employ mechanical mixers. But in a year or so, process requirements are expected to change, throwing 15% greater load on the mixers.

Problem: how can the engineer anticipate the change now so as to avoid heavy replacement costs later on?

Solution proposed by the LIGHTNIN Mixer representative: install standard turbine-type LIGHTNIN Mixers geared for the immediate job, but sized to handle the expected load.

When requirements increase, simply change impellers and two gears in each mixer—providing correct power input for the new conditions at minimum expense.

This is one example of many ways your LIGHTNIN representative can help you get efficient fluid mixing at lowest long-term cost.

What this man can do for you

He can give you better service on fluid mixing than anyone else—because he has seen and done more of it.

He helps you stay ahead of competition, by bringing you the newest mixing developments first.

He gives you the assurance of being *right,* because his recommendations stem from years of field work, plus realistic pilot-run data developed at MIXCO. We back him up by guaranteeing results, unconditionally.

Take advantage of his unmatched experience by putting him on your process-design team. For prompt help on any fluid mixing operation, call him in now. He's listed in Chemical Engineering Catalog. Or write us direct.

Lightnin® Mixers

MIXCO fluid mixing specialists

MIXING EQUIPMENT Co., Inc., 164-e Mt. Read Blvd., Rochester 11, N.Y.

In Canada: Greey Mixing Equipment, Ltd., 100 Miranda Ave., Toronto 10, Ont.

You "Oughta" Build Now

WOULD YOU CALL the man crazy who told you that *today* rather than *tomorrow* is the time to build? At first blush you might, but if you'll get right down to cases you might find reason for changing your mind.

Because there is ample evidence that you could hardly pick a better time than right now to go forward with any building or expansion which you might have in mind. Even if you cannot see your markets increasing enough to justify a new plant, how about striking now to remove those bottlenecks and/or reduce wasteful leaks that have shown up? Thus you would have your plant in position for making a better product at less expense and thus be ready for tomorrow's increased markets.

Surely you have plotted the expected growth curve for your products and know all thats "knowable" about what the future holds. Should you be hesitant because there is a slight slump in these demand curves? If you do, you might be caught in tomorrow's expansion race. *Today,* not tomorrow, you can make the best deal on new plant engineering and construction. Here's why, our observations tell us, you can get more plant for your money *now:*

Today's Advantages. 1. Today equipment deliveries are normal. You can expect and get, better delivery and more thorough engineering. It's a buyer's market. Take advantage of it!

2. These normal times also mean the best prices on equipment. Shops are needing work and firm orders will be tabbed with price tags even better than you'd expect.

3. Today the ulcer-causing expediting racket has slipped into the background. Your project will be completed sooner and money need not be allotted for those contigencies that are necessary during "crash" building programs.

4. The "deadwood" has been trimmed from all engineering staffs. Only the best and most productive people have survived. You will get "custom" treatment and also the best product of the best engineering talent.

5. Under today's conditions you won't have to rush into engineering. Time can be taken for careful planning and many of the bottlenecks that crop up in the finished plant can be eliminated in advance.

"Getting it wholesale" has never meant more than it does *today.* Manpower availability, equipment deliveries and prices are at their normal best. You can be ready for tomorrow's upturn and avoid the rat race of emergency construction.

Money Savers. Just what this means to the refiner and petrochemical plant operator can be pointed out quickly in money-saving numbers:

First, he can build a plant with approximately 10 percent less capital investment. Also he can demand and get a better engineered plant. These better designs will reflect themselves in lowered production costs and savings in maintenance. There will be higher profits. Lower capitalization means lower taxes. All of this adds up to more plant for less money.

Second, he can take advantage of *tomorrow's* increased demands at the most competitive price by getting his best planning heads together, setting his ducks in a row and going ahead with projected plans. As sure as there is a tomorrow, there will be an upturn in demand. One word of caution, however, is to be able to take advantage of *today's* conditions, a manufacturer must know, or feel, the future turn of events. This tremendous flywheel, turning somewhat slowly today, will surely speed up tomorrow. Now's the time to get ready for any sudden accelerated demand.

Third, he can get more and better engineering. There is no engineering shortage! Even the junior engineers have had substantial experience on past projects. Thus, he can be assured of "preferential" treatment as far as engineering is concerned. Engineer-designers are at their best *today.* Attention to the last and least detail in plant design is assured. There will be the most efficient application of the best engineering talent.

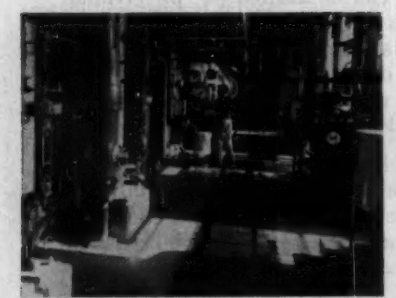
Fourth, he will have planned plant completion. With *today's* equipment deliveries, there will be no waiting for that last piece of equipment. Construction craftsmen are available to do the job better and faster. The newest cost-saving construction and fabrication techniques are being used. Completion well ahead of schedule can be expected. This means a plant when he wants it, all tested and ready to pro-

Du Pont FOA-2 is added to residual fuel as it's pumped into sludge-ridden tank.

$20 worth of FOA-2 saved $800 desludging job ... and with no downtime

A power plant serving two industrial laboratories burns between 1,000 and 1,500 gallons of residual fuel, daily, from a 50,000-gallon tank.

Recently, it was discovered that six inches of sludge had accumulated in the bottom of the tank. Constant temperature had to be maintained in the laboratories, so a tank-cleaning firm was called in. They gave a firm estimate of $800 for cleaning the tank mechanically. Considerable downtime would be required.



This is the powerhouse that *had* to maintain service, so that essential temperature control, in the laboratories it served, could also be maintained.

Looking for an alternative, the power superintendent decided to try using Du Pont Fuel Oil Additive No. 2 to break down the sludge. After one week of operation, during which only $20 worth of FOA-2 was used, no sludge could be detected. Moreover, there was no downtime. *The tank was in use all during the clean-up period.* Boiler room operations were completely trouble-free throughout the time the sludge was being dispersed and burned with the oil.

In addition to sludge removal, prevention of sludge is an improvement FOA-2 gives residual fuels. It is an excellent stabilizer, solubilizer, and dispersant.

Being nonmetallic, the additive burns with the fuel, leaving neither ash nor other residue. Refiners as well as their customers profit from the use of FOA-2, because it helps to stabilize all forms of distillate fuel oils, as well as residual fuel. These include blends such as catalytic-cracked stocks combined with straight-run products.

Your Du Pont representative can give you further details. Or write for a copy of our comprehensive 24-page FOA-2 book. It contains complete technical and experimental data. E. I. DU PONT DE NEMOURS & CO. (INC.), Petroleum Chemicals Division, Wilmington 98, Delaware.

See the "DU PONT SHOW OF THE MONTH" on CBS

DU PONT

Better Things for Better Living ... through Chemistry

Tetraethyl Lead and other Petroleum Additives

duce a top notch product for *tomorrow's* expanding market.

Ten-Percent Share. Fifth and perhaps most important, to take advantage of these timely conditions, he must be ready. Now is the time to start advanced engineering studies. There's excellent manpower available for the first time for doing just this. He can study, revise, pare and add to at minimum cost today. Still the standard quotation may be at yesterday's price, but firm orders can be shaved about 10 percent. This may be bettered by shopping around, and today he can do this. No longer must equipment inquiries be confined to only one or two manufacturers. Everybody needs the business and all will give the best service and delivery. The important point is—he must be serious and go out for inquiries with immediate purchase in mind.

You'll seldom find a "bird nest on the ground" as you can *today*. Rarely have conditions been so good for the *buyer*. Dust off those plans, get the purchase orders typed and get ready for *tomorrow today*.

Another Use of A Foul Tactic

"UNDER THE PECULIAR PROCEDURE of this Senate investigation, the chairman of the committee 'invites' you to testify and then issues a flood of statements to the newspapers denouncing the character, motives and antecedents of your business. He begins the hearing by reading a statement pronouncing your business guilty of all kinds of unsavory practices; after which you are assured in a friendly manner that the committee will now launch a completely unbiased investigation of the facts. But when the true facts have been presented, they are ignored or misused, and the chairman and his staff bring in a report confirming all of the preconceived notions set forth in his opening statement. This proves he was right all the time."

Speaking is Roger M. Blough, chairman of the board of United States Steel Corporation, who thought "Senator Kefauver's statement attacking steel prices gives a thoroughly biased and distorted view of the testimony that was presented to his subcommittee."

Blough here describes a tactic that has been used too many times in Washington. It has been a favorite manoveur by several "statesmen" who apparently take great delight and every opportunity in making a whipping boy of the oil industry.

This sort of thing is flagrantly unfair and the Senate and the House of Representatives should take the necessary steps regarding committee procedure to forbid its use by their members. Certainly it isn't too much to rule out the use by high government officials of a weapon that is patently unfair.

Another thought: Business, if it presented a united front on such matters, likely could force a change. We just can not believe that public opinion would back men, be they U. S. Senators or just plain thugs, in the use of such tactics.

A Modern Gladiator

ONE LARGE AMERICAN CORPORATION, General Electric, has decided to stop all fence straddling and start taking sides on issues which affect American business.

Congratulations GE! The time is always ripe for more champions of American free enterprise to show a willingness to step into the political arena and show its corporate muscles.

General Electric officials have reasoned, and rightly so, that the company as well as its employes have a stake in the many issues decided by government at the local, state, and federal levels. These officials will seek appearance before legislative committees to present the company's view on issues under consideration, and will offer counsel and advice to government officials.

The company may even urge employes to support candidates who favor GE-backed policies, regardless of the political affiliation of the candidate.

One company officer summed up the new policy with, "We intend to speak out on every major issue where we feel we can make a contribution."

Now that big GE has taken the bigger step, the door is wide open for other large corporations to follow. We don't doubt that factions will become offended from time to time by such forthright tactics, and perhaps even contracts, including those that emanate from Washington, will be lost. But business had better speak and act its piece on a day-to-day basis if it expects to have the influence nationally that it deserves.

When Worms Are Scarce

A WARNING that should not be needed but a timely one in view of the economic situation was sounded recently by Dr. Haldon A. Leedy, director of the Armour Research Foundation of Illinois Institute of Technology.

Leedy cited the long-range vision of business firms and government agencies for not reducing research expenditures in a period of recession trend. He pointed out that it takes an average of five years from the inception of a research project to the final reality of a new or improved product or process. Because of this, he said, any serious curtailment of research funds would not be immediately apparent, but could affect the nation's economy and national defense advancement at a time when such knowledge is needed most.

"Continued investments of ample funds in carefully-planned research projects," Leedy said, "can be an effective 'shot in the arm' during our present economic situation and at the same time provide the assurance of the further expansion of our economy."

Truly it is a shortsighted policy that would permit a slowdown of research just because dollars seem scarcer than, say, a year ago. Actually during these times oil companies should be scratching the harder—and isn't research just that?

ETHYL RESEARCH APPRAISES VOLATILITY PROBLEMS OF FUTURE FUELS

Another important phase of octane improvement cost studies which must be balanced with engine requirements

Volatility cannot be separated from octane improvement cost studies of present day and future fuels. Exactly how much effect volatility will have upon cost studies will depend upon the individual refining situation and the value and/or availability of various pressurizing materials.

Studies in this field show that volatility is frequently a limiting factor in fuel composition.

Volatility and Engine Appetite

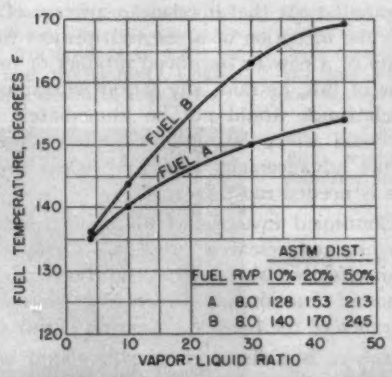
The importance of volatility as it relates to cost of octane improvement cannot be minimized. Yet engine acceptance of proposed volatility specifications must be given careful consideration. This is not always a straightforward comparison with previously marketed products.

Studies of refining trends made by Ethyl engineers indicate that volatility control of future fuels may become a subject for very careful appraisal as it relates to satisfactory engine performance.

Refining Trend— To More Aromatics

The refining trend within the next few years is toward higher aromatic fuels. Refinery practices such as splitting reformate, extraction of aromatics, and allocating more feed to the reformer all will be contributing factors. As more aromatics are blended to gasoline, there is an attendant decrease of mid-volatility

FIG. 1
EFFECT OF ASTM DISTILLATION ON THE VAPOR-FORMING CHARACTERISTICS OF GASOLINE



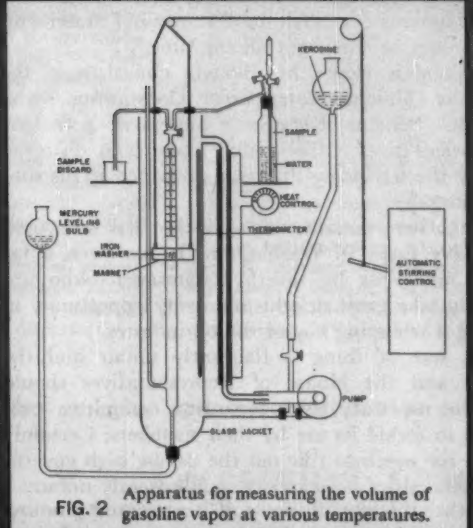


FIG. 2 Apparatus for measuring the volume of gasoline vapor at various temperatures.

For more data on advertised products, use Readers' Service Cards, last page.

ETHYL'S SAN BERNARDINO LABORATORY is ideally situated and well equipped for general studies of fuel volatility. Maximum daytime temperatures near 100°F. prevail throughout the long summers. Suitable test roads are available at various altitudes.

as shown by the ASTM distillation curve.

Ethyl experience has shown that this frequently will hamper warm-up characteristics of today's engines. *Warm-up* has been given very careful consideration in Ethyl fuel studies since this is a vital aspect of mid-volatility.

Very often mid-volatility problems will require complete rebuilding of the fuel with maximum use of light blending components such as iso-pentane.

Precautions with Iso-Pentane

From the standpoint of engine acceptance, iso-pentane must be carefully appraised. Vapor lock is probably the most important single factor that must be considered. Vapor formation proceeds at a very rapid rate in fuels that are pressurized with large quantities of less volatile pentane, once designed-for fuel temperatures are exceeded.

An evaluation must be made for any volatility change. However, more care must be exercised in the control of a pentane-pressurized fuel than one adjusted with butane since more severe vapor locking difficulties can result during unseasonably hot weather.

Can Vapor Lock Tendencies Be Estimated?

The rates of vapor formation at various temperatures determine the relative vapor locking tendencies of gasolines. Vapor formation is not necessarily related to Reid vapor pressure alone.

One method of arriving at this information is shown in Fig. 1. Two fuels of the same Reid vapor pressure but different ASTM distillation curves are indicated. Fuel A produced 30 volumes of vapor per volume of liquid at 150°F., whereas Fuel B formed only 16 volumes at the same temperature.

The above type information (temperature V/L values) may be calculated from usual gasoline inspection data using Coordinating Research Council procedures.

Experience may then relate the temperature—V/L values to vapor locking tendencies of cars under seasonal conditions for the area of interest. Such an appraisal permits a more accurate specification of desired front-end volatility.

Frequently it is necessary to cross-check temperature V/L values of fuels having unusual distillation characteristics by an experimental procedure. Apparatus for such laboratory work is described in Fig. 2. This equipment is available at the San Bernardino branch of Ethyl Corporation's Research Laboratories.

Other facilities there include a gasoline testing laboratory, and a chassis dynamometer which operates under controlled temperature, wind and velocity conditions. Ethyl Technical personnel have frequently used these facilities in cooperation with refiners for studies of their gasoline volatility problems.

HOW ETHYL RESEARCH IS HELPING YOU

The Refining Industry is constantly studying volatility of future fuels as it relates to octane improvement.

Ethyl Corporation Refinery Technologists have recently made a precise study of butane and pentane to establish the octane blending values of these pressurizing agents in several refinery stocks.

Refining trends indicate that iso-pentane will find a position in future fuels for octane improvement and volatility control. Future fuel volatility should be carefully appraised from the standpoint of engine acceptance. Assistance in such studies, based on over 30 years' experience in fuel-engine relationships, is available from Ethyl's Research Laboratories.

For further information, just call your Ethyl Representative.

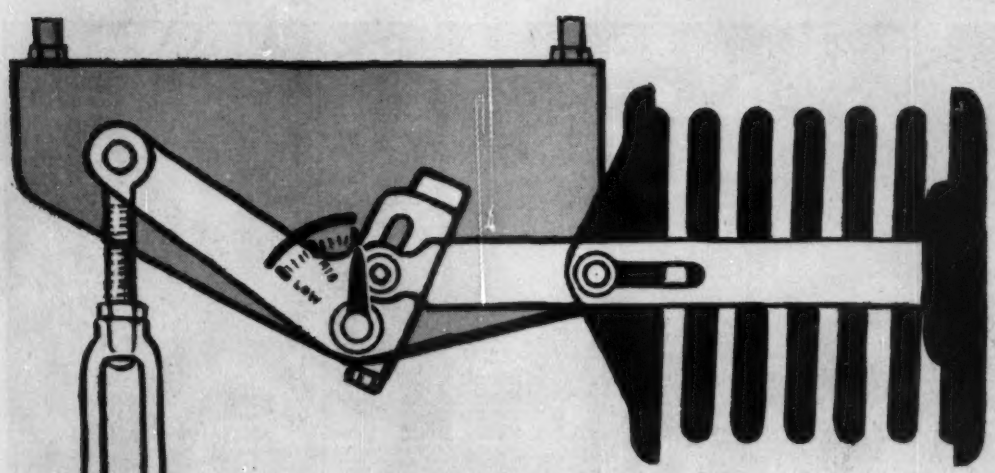
ETHYL CORPORATION

New York 17, N. Y.

ETHYL ANTIKNOCK COMPOUND — ETHYL CORPORATION

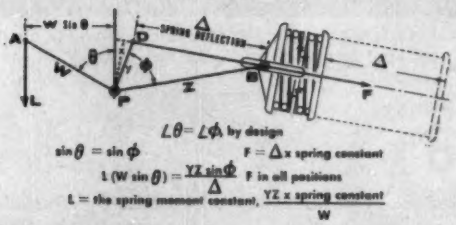
RESEARCH LABORATORIES:
1600 W. Eight Mile Road, Ferndale 20, Mich.
2600 Cajon Road, San Bernardino, Calif.

For more data on advertised products, use Readers' Service Cards, last page.



Mathematically Perfect Pipe Support!

The exclusive geometric design of the Grinnell Constant Support Hanger balances the moment of the vertically shifting load with a mathematically equal spring moment at every point throughout the full range of travel.



$\angle\theta = \angle\phi$ by design

$\sin\theta = \sin\phi$ $\quad F = \Delta \times$ spring constant

$L\,(W \sin\theta) = \frac{YZ \sin\phi}{\Delta}\,F$ F in all positions

L = the spring moment constant, $\frac{YZ \times \text{spring constant}}{W}$

GRINNELL CONSTANT SUPPORT HANGERS

may be adjusted over a 70% range of load carrying capacity, as indicated by the divisions on the load scale. When factory-adjusted to a specified load within this range, there always remains not less than 10% for additional field adjustment.

Compact design, resulting in small size for the load supported, makes Grinnell Constant Support Hangers easy to install—allows their use where only limited head room and space for close nesting are available. Simplicity of design makes these hangers easy to maintain.

Grinnell designs, manufactures and supplies pipe hangers and supports for every piping requirement.

In addition, Grinnell offers the services of trained field representatives and design services for consulting engineering firms. Contact Grinnell for your future hanger requirements.

Only Grinnell Hangers provide true constant support, plus these features:

- 5 frame sizes provide a range of travel from 1½ inches to 12 inches and support loads from 30 to 32,260 pounds.
- Load deflection curve is a horizontal straight line, at *every* setting on the load adjustment scale.
- Antifriction needle roller bearings are provided at all critical pivot points.
- Low ratio between spring force and supported load reduces friction, permits smaller size hangers for loads carried.
- Travel stop is a permanent attachment — always available for temporary use to set hanger into nonoperative position for underload or overload.

GRINNELL

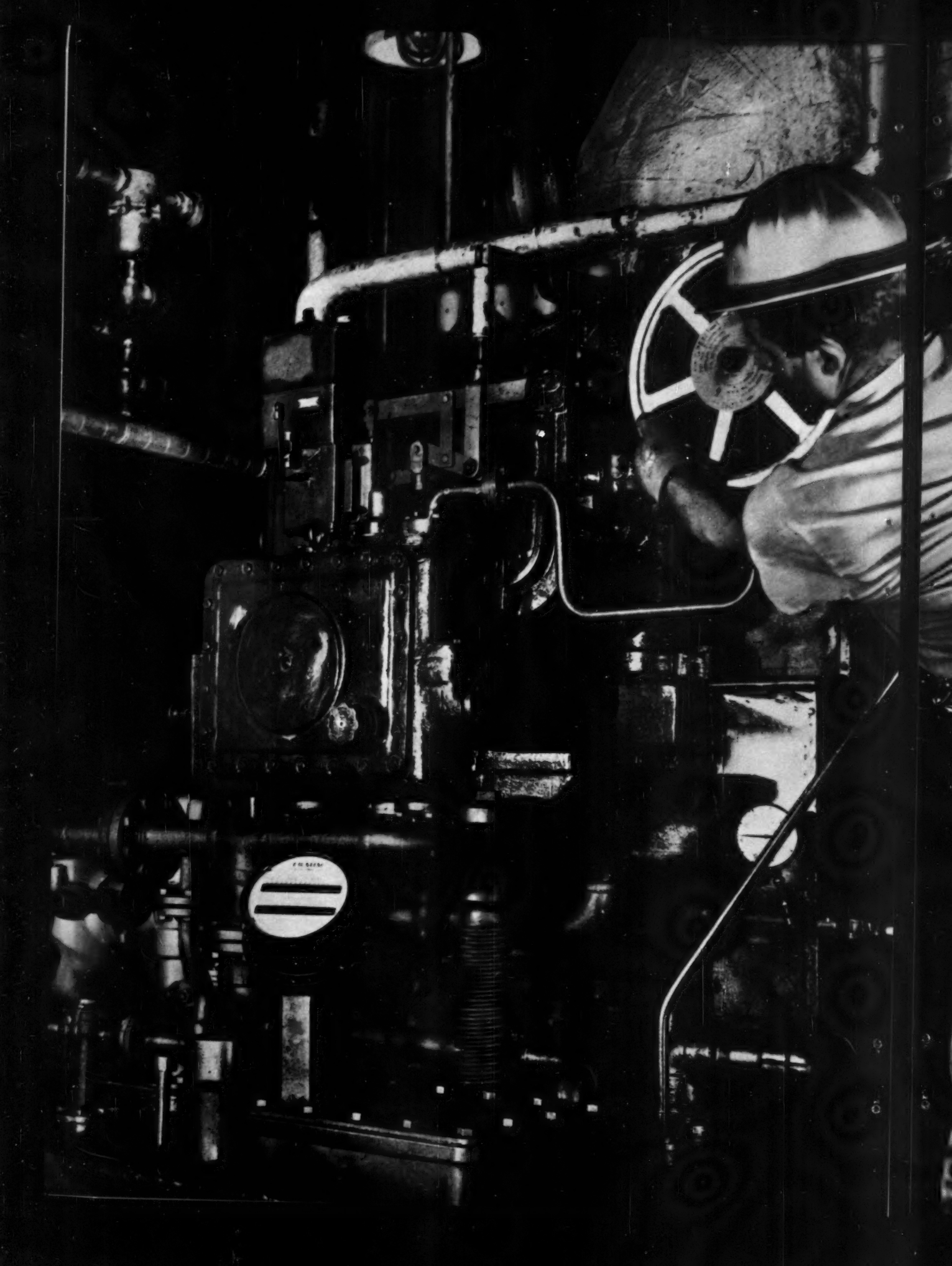
AMERICA'S #1 SUPPLIER OF PIPE HANGERS AND SUPPORTS

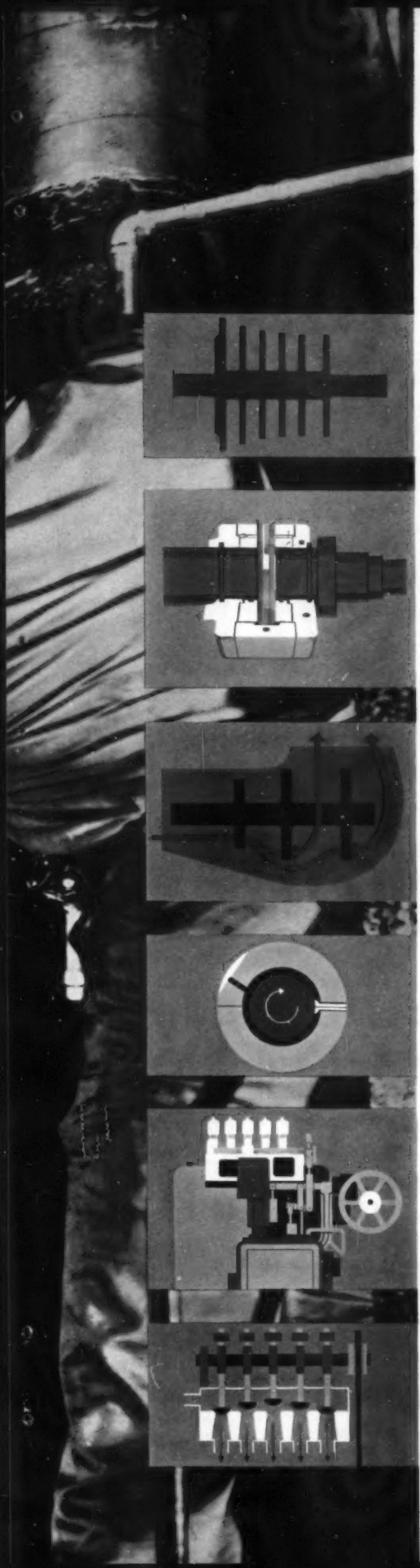
Grinnell Company, Inc., Providence, Rhode Island • Coast-to-Coast Network of Branch Warehouses and Distributors

pipe and tube fittings • welding fittings • engineered pipe hangers and supports • Thermolier unit heaters • valves Grinnell-Saunders diaphragm valves • pipe • prefabricated piping • plumbing and heating specialties • water works supplies industrial supplies • Grinnell automatic sprinkler fire protection systems • Amco air conditioning systems

HOW TO SAVE MONEY BY SPENDING IT!

PAY EXTRA NOW FOR 6 BASIC RELIABILITY FEATURES OF WORTHINGTON HIGH-SPEED TURBINES AND AVOID THE EXCESSIVE COSTS OF DOWN-TIME LATER





Worthington High-Speed Turbines cost more to build, are used more, are worth more

(these 6 reliability facts are some of the reasons why)

Reliability Fact #1

SOLID ROTORS keep wheel stresses well within safety margins. Where needed, wheels forged integral with the shaft are used to meet the demands of modern high speeds. Solid rotor construction, a sure method of holding wheels on the shaft, provides a more rugged conservative design. Solid rotor also decreases length of turbine, thus simplifying critical speed problems and adding to efficiency.

Reliability Fact #2

KINGSBURY-TYPE THRUST BEARINGS withstand heavy thrust loads with small friction loss and low rate of wear. Bearings have babbitted surfaced multi-segment shoes that pivot on hardened buttons. This pivoting action forms a wedge-shaped oil film between the rotating thrust collar and the shoe bearing surface. This has a cushioning effect in case of unusual shock loads in either direction. The thrust load is automatically distributed equally to the several shoes thereby maintaining internal alignment as well as holding the rotor in its axial position.

Reliability Fact #3

DOUBLE-FLOW exhaust construction on Worthington turbines reduces operating stress and increases efficiency in the handling of large volumes of steam at high speeds. Steam is divided ahead of the last stage and directed through separate rows of revolving blades before leaving via a common exhaust. Double-flow exhaust construction allows reduction in last-stage wheel size and blade length, which reduces wheel and blade stress and makes possible a simplified blade design. This permits improved nozzling with consequent efficiency increase.

Reliability Fact #4

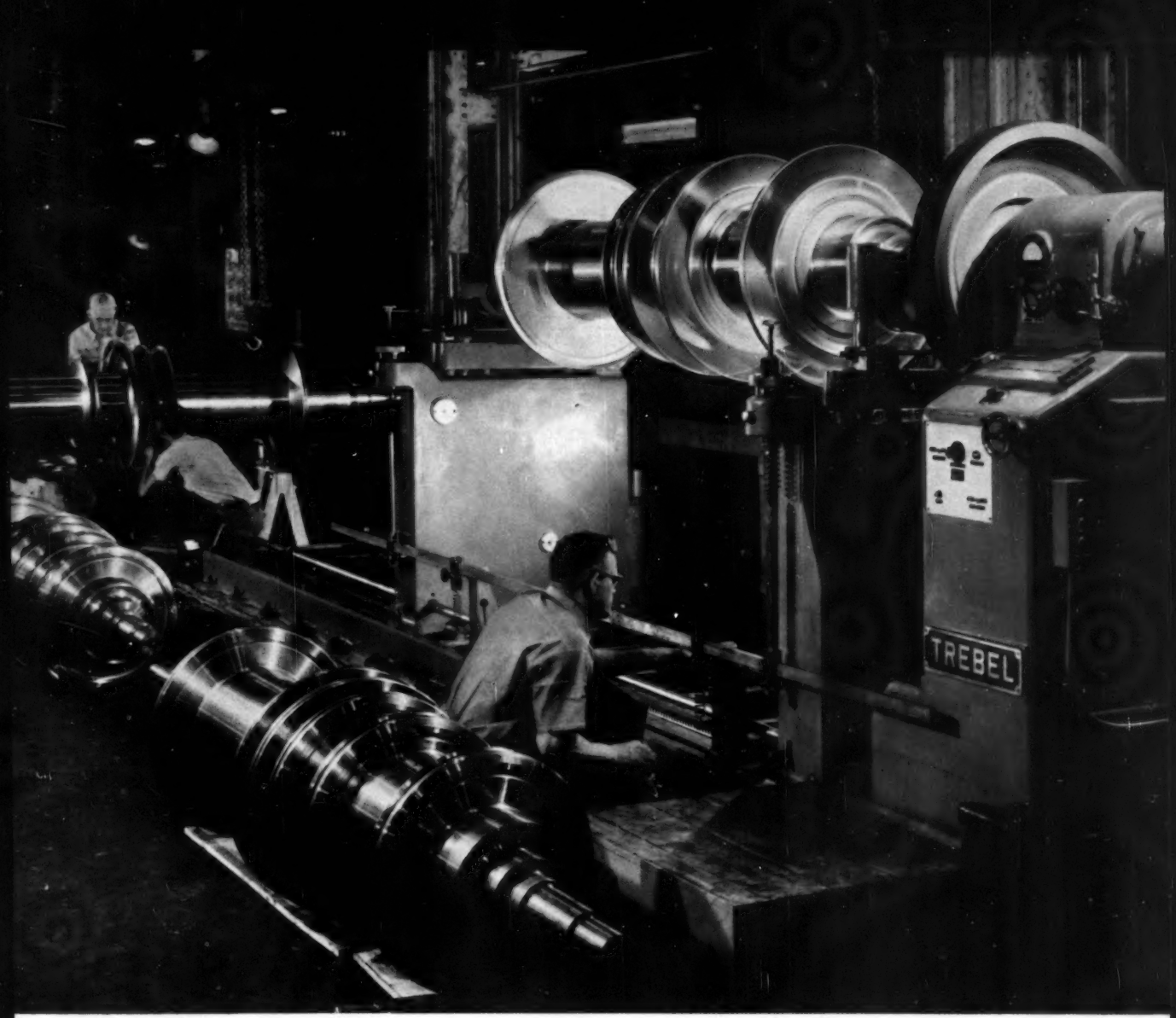
ANTI-OIL-WHIP BEARINGS are standard on Worthington high-speed turbines. A dam in the upper half of the bearing builds up a pressure pad of oil during operation. The pressure creates a downward force on the journal holding it firm in the bearing, thus keeping vibration to a minimum. Anti-oil-whip design increases life, cuts maintenance expense on bearings.

Reliability Fact #5

SENSITIVE SPEED GOVERNING SYSTEM with integral air motor combines extremely close regulation with a broad range of speed adjustment. Governor takes air impulses from an outside controller to vary speed of turbine in accordance with controller's impulse. Sensitive governor is capable of maintaining the output from the compressor substantially constant. Regardless of changes in load or steam conditions, the turbine is always under control of the speed governor, governing at any speed for which the air motor is set.

Reliability Fact #6

MULTI-VALVE AUTOMATIC NOZZLE CONTROL assures most economical operation of the turbine at all loads. Each valve automatically controls the admission of steam to a separate group of nozzles, and is operated by an independent cam mounted on a camshaft. The cams are shaped to give any desired rate of opening. The entire mechanism is mechanical, positive, and far superior to other lower-cost designs.



Balancing rotor for a 6,000 hp Worthington high-speed turbine.

THE MEANING OF LEADERSHIP

Long, trouble-free life of Worthington high-speed turbines stems from two primary sources. One: the multiple achievements of Worthington engineers. Two: the wide variety of tests to which machines are subjected before shipment to customer. Worthington, for example, is the only manufacturer that load-tests all multi-stage turbines. In this process, the turbine is coupled to a water brake so that its precise behavior under actual performance conditions can be predicted. Only when the turbine has passed this — and many other exacting tests — is it approved for shipment. This infinite attention to detail, this painstaking insistence upon perfection, explains why Worthington is today the nation's undisputed leader in high-speed turbine installations. 48-2

WORTHINGTON

WORTHINGTON CORPORATION, HARRISON, NEW JERSEY

IMPORTANT NEWS

Major causes of refinery fouling and corrosion can be eliminated at the crude unit

SEVERE corrosive and fouling agents can now be removed from the crude oil charge before they can do damage. The new CRONOX® C conditioning treatment* rids crude hydrocarbons of dangerous impurities by harmless chemical action. Refineries treating their crude charges with CRONOX C conditioning have greatly extended time on stream and equipment life, while cutting cost and length of turnarounds.

CRONOX C conditioning treatment neutralizes hydrochloric and naphthenic acids, minimizes attack due to highly corrosive organic agents. It scavenges oxygen from the oil, thus retarding attack by hydrogen sulfide and reducing the formation of fouling deposits.

Inject CRONOX C conditioning solution into the crude at the charge pump. Preheat exchangers, crude heaters, crude distillation towers, overhead equipment and bottom exchangers are remarkably free from attack or deposits. The crude unit is safeguarded, and its refined products are less capable of fouling or corroding subsequent equipment.

To learn how you can eliminate major causes of refinery fouling and corrosion easily and economically, ask Aquaness for the new booklet on CRONOX C conditioner. Write today, using the coupon below.

ATLAS

Aquaness *Department*

ATLAS POWDER COMPANY

2005 Quitman Street, Houston 26, Texas

*Patent applied for

Aquaness Department
ATLAS POWDER COMPANY
2005 Quitman Street, Houston 26, Texas

☐ Please send me a copy of the new booklet on Cronox C conditioner.

Name _____

Title _____

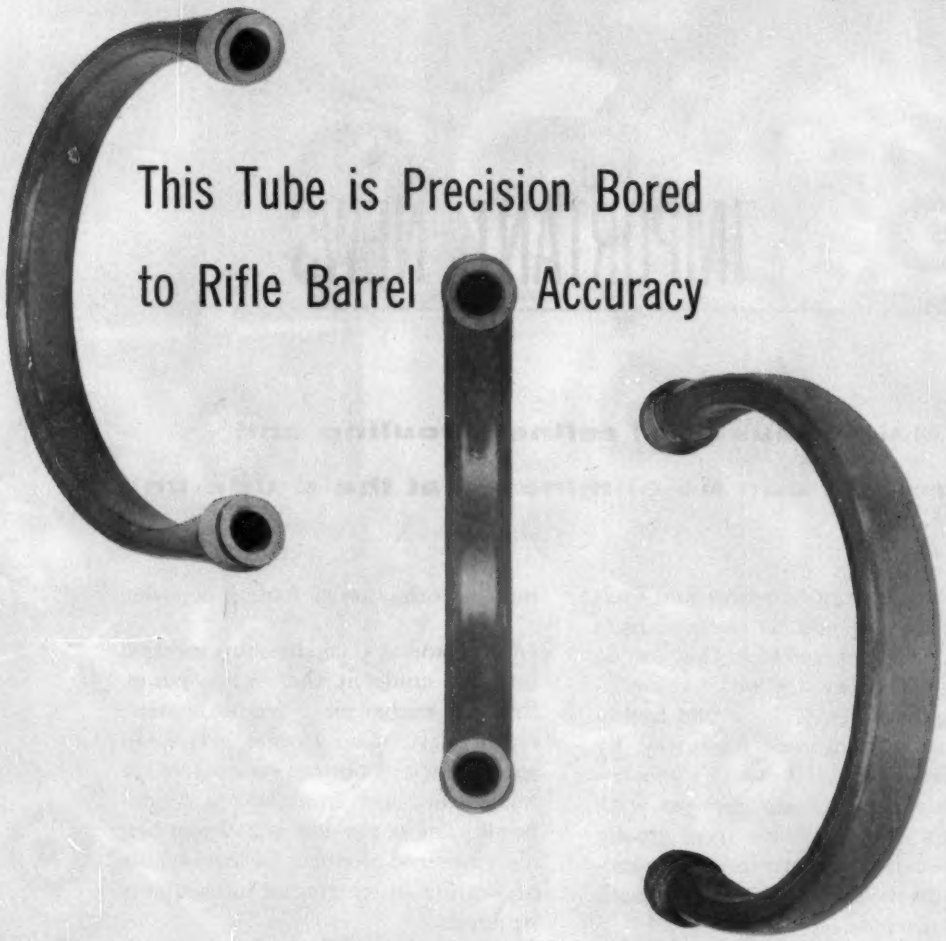
Company _____

Street _____

City _____ Zone ____ State _____

For more data on advertised products, use Readers' Service Cards, last page.

This Tube is Precision Bored to Rifle Barrel Accuracy



Ashcroft Duragauge in Phenol case — a tough, rigid plastic turret type case for wall or flush mounting.

The Bourdon tube in Ashcroft Duragauges is machined mirror-smooth inside and finish ground outside to exact tolerances. Strong, uniformly thick walls assure precise flexibility—sustained high accuracy and long life.

Eight tube materials permit you to select the best metal with sensitivity balanced by internal corrosion resistance. Whether your choice is phosphor bronze, an alloy steel, "K" Monel, a stainless steel or beryllium copper, metallurgical control is exact from ingot to finished tube. Socket and tip joints are welded or brazed, then stress relieved for highest strength and safety. "Whip testing" at pulsating pressures at least 50% greater than rated pressure insures calibration stability.

Order your Ashcroft Duragauges with the best Bourdon tube material for your service. Choose the all-stainless-steel movement or stainless steel with nylon bearings and pinion gear. Full range of pressures, dial sizes, case designs and materials available. In any combination of components, Duragauges give sustained high accuracy and long service. Get details from your industrial supply distributor.

MANNING MAXWELL & MOORE, INC. M&M TRADE MARK

G2-58

ASHCROFT PRESSURE GAUGES

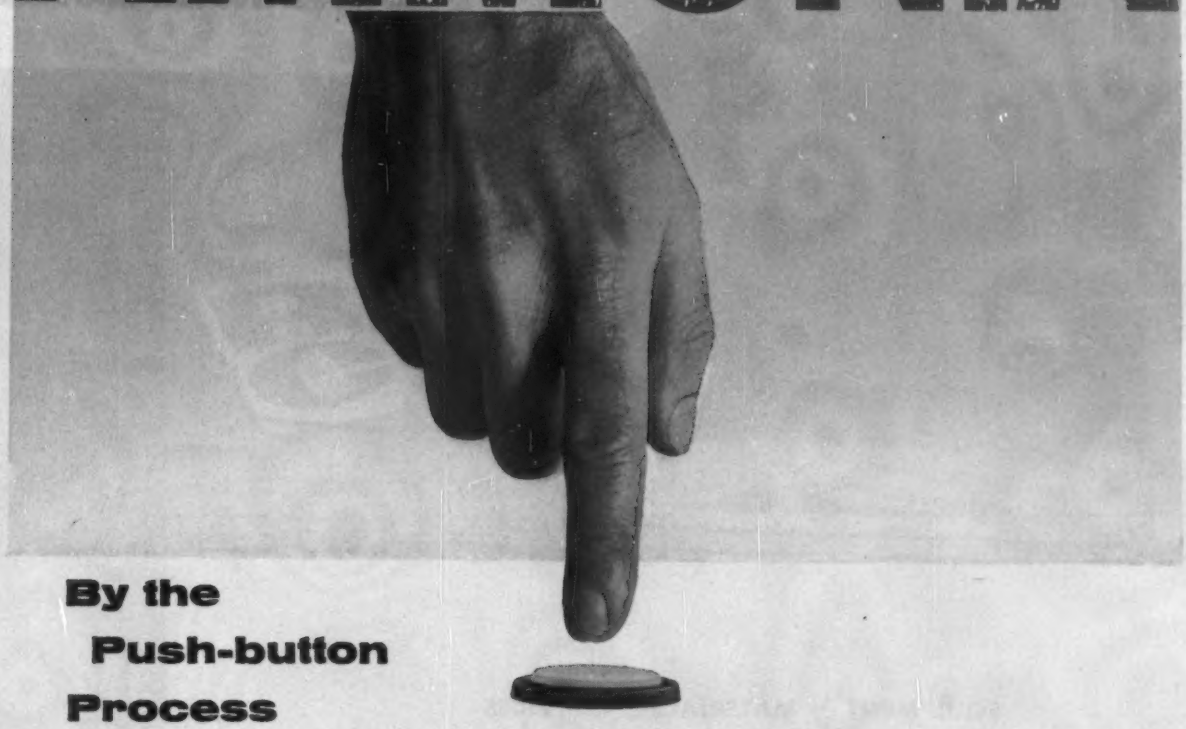
A product of

MANNING, MAXWELL & MOORE, INC.

Consolidated Ashcroft Hancock Division • Stratford, Connecticut

In Canada: Manning, Maxwell & Moore of Canada, Ltd., Galt, Ontario

AMMONIA



By the Push-button Process

Ammonia plant start-up operations are virtually a matter of "push-button" routine with Chemico; for Chemico has designed and constructed more than 50 ammonia plants in the last 40 years.

While new-comers to the field are constantly running into costly difficulties and delays with unreliable and even untried processes, Chemico designed plants are profitably producing an estimated 25% of the world's synthetic ammonia. Investors in the chemical industries may be interested to learn that despite the proven performance and countless advantages of Chemico's ammonia processes, it frequently costs less to build a Chemico Plant.

Write today for Chemico Bulletin #357 which lists the alternate feed stocks and methods for gas purification and production in the making of ammonia. .

CHEMICO

CHEMICAL CONSTRUCTION CORPORATION
525 West 43rd Street, New York 36, New York

CHICAGO • DALLAS • HOUSTON • PORTLAND, ORE. • TORONTO • LONDON • PARIS • JOHANNESBURG • TOKYO

For more data on advertised products, use Readers' Service Cards, last page.

300

25th ANNUAL EDITION

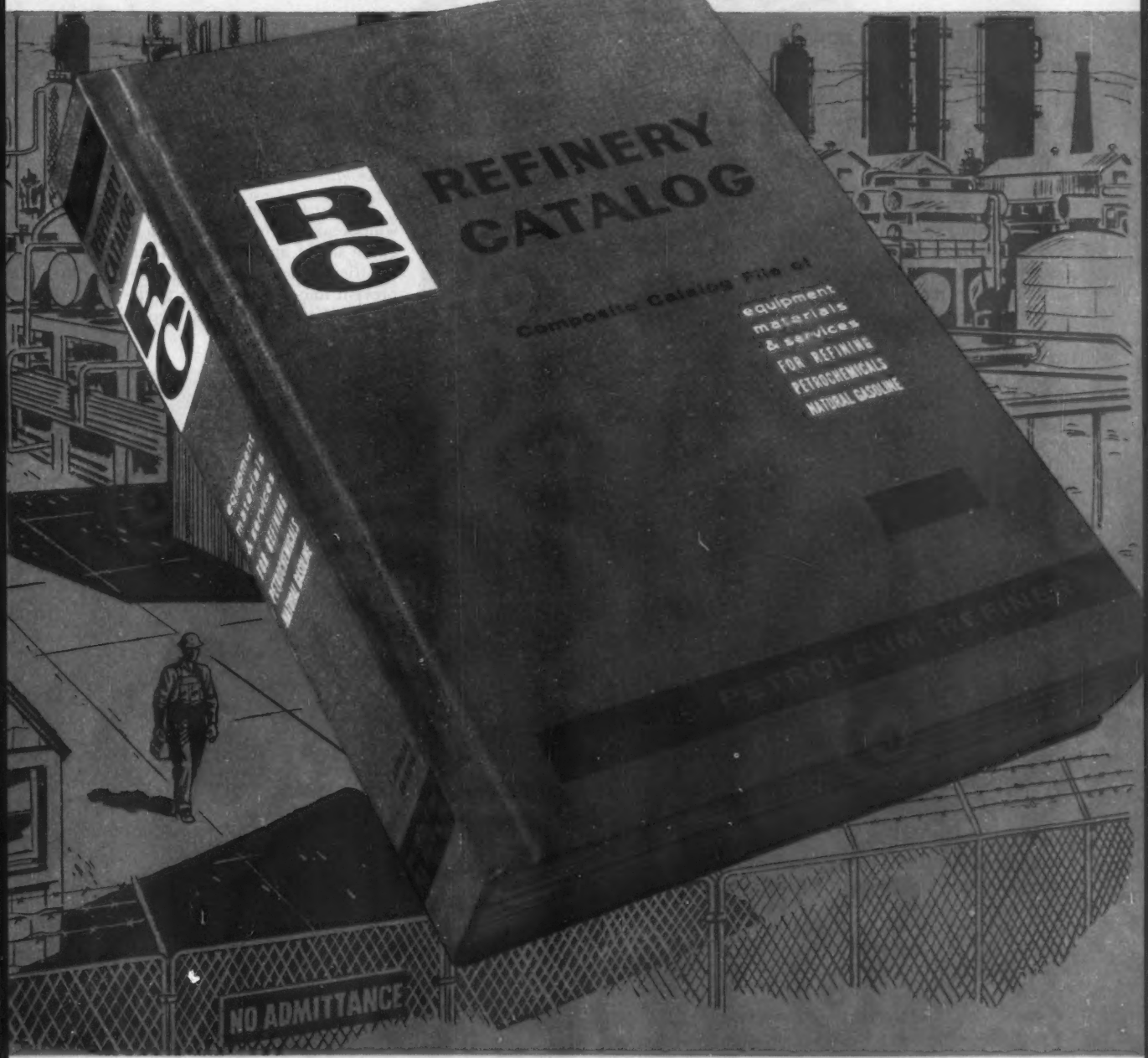
EQUIPMENT • MATERIALS • SERVICES
for REFINING • NATURAL GASOLINE • PETROCHEMICALS

In a hurry? Eight out of nine planners, buyers and specifiers turn to REFINERY CATALOG in preference to individual suppliers' literature when figuring a job. They know that REFINERY CATALOG is always current, that it's indexed and cross-indexed for quick, accurate reference. That's why more than 300 manufacturers and service companies put their complete or condensed catalogs in REFINERY CATALOG. Here they are "on call" 24 hours a day.

The next time *you* have a procurement problem, reach for a quarter-century of cataloging experience—look *first* in the one volume, easy-to-use REFINERY CATALOG.

SUPPLIERS ON CALL

OF REFINERY CATALOG



REFINERY CATALOG

Published by Petroleum Refiner

For more data on advertised products, use Readers' Service Cards, last page.

How to Design a New Smokeless Flare

This new multijet flare requires no steam or water to make it smokeless and promises an economical solution to most flaring problems.

P. D. Miller, Jr., and H. J. Hibshman
Esso Research and Engineering Company, Linden, N. J.
J. R. Connell, Imperial Oil Limited, Sarnia, Ontario, Canada

A NEW TYPE of refinery flare, called multijet, has been developed by Esso Research and Engineering Company. The new flare—which burns with no smoke, no noise and no visible flame—promises an economical solution to ever increasing flaring problems facing many refineries today.

Esso Research was assigned the problem of developing a better flare in 1954. Pilot plant studies were completed in the summer of 1955. A prototype multijet was put in service in late 1956 at the Halifax refinery of Imperial Oil Limited. This flare has operated successfully whenever required, including a continuous period of three months. Other multijets are being designed for Standard Oil Company (New Jersey) affiliates. Complete design details are being made available as a service to the industry.

COMMERCIAL OPERATION

Imperial Oil's Halifax refinery afforded the first opportunity for commercial installation of the new flare. The refinery was already equipped with an elevated flare which would continue in service as a major emergency flare. The multijet was needed to handle the more frequent, smaller emergencies and to dispose of any net surplus of refinery fuel gas. The flare design capacity was set at 2.1 million standard cubic feet per day of a 40 mol weight gas, or about 200 million Btu. per hour.

Figure 1 is a photograph of the two flares taken about a year ago. The multijet's stack has an inside diameter of 12 feet and is 32 feet high. The bottom of the stack, which is 6 feet above the ground, is protected by an 8-foot high shield, or "windbreaker." Figure 2 is a close-up of the multijet. The burner piping and jet grid are positioned several inches below the bottom of the stack. The stack is lined with two courses of firebrick, providing a total insulation thickness of 9.4 inches.

The first design of the louvered windbreaker proved to be an inadequate shield against light. There was insufficient overlap of the blinds to prevent line-of-sight vision to the bottom of the stack, causing appreciable

FIGURE 1—Here is an elevated flare and the new multijet at Imperial Oil Company's Halifax refinery.

ground-glow at night. Inasmuch as the temporary solid shield seems to cause undesirable wind eddies, it will be replaced with an improved louvered type of shield.

The first flameholders were solid, fused alumina rods; these rapidly deteriorated and were replaced with silicon carbide. No further difficulties with the flameholders have been reported.

COSTS

Table 1 compares the costs of several types of flares. When permitted by local conditions, the simple elevated flare is always the first choice. But when it is necessary to minimize smoke, an elevated flare quickly loses its advantage. The initial cost of the new steam facilities for the flare is more than three times the cost of the flare itself. In special cases where steam can be temporarily diverted from noncritical consumers, such as

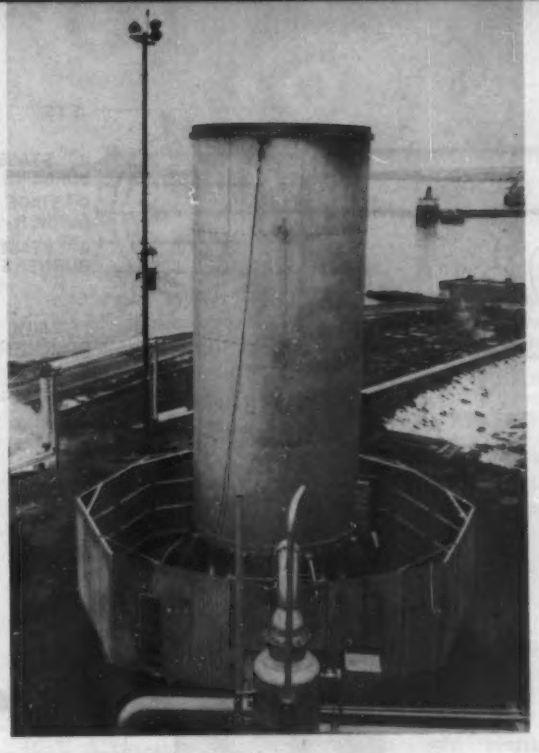


FIGURE 2—The new multijet flare is shown here with a temporary windbreaker and the second stage seal drum in the foreground.

How the multijet flare was developed . . .

Although considerable data were available on flame length, there seemed to be little information on the variables which determine whether or not smoke is formed. Accordingly, experiments were performed to establish conditions for essentially smoke-free combustion. These experiments studied jet diameter, velocity, and spacing.

OPEN AIR TESTS

Jet Diameter—First, single jets were tested to establish upper limits on the diameter. Half-inch and 1-inch diameter jets were reasonably satisfactory. However, a 2-inch diameter jet (operating at about 75 feet per second) resulted in a large and fairly smoky flame. When the same amount of gas was burned in nine ½-inch diameter jet short, smokeless flames resulted.

Jet Spacing—The effect of jet spacing was studied with nine ½-inch diameter jets. Jet spacings of 9 inches, 15 inches, and 27 inches were used with a square layout (jets located on a checker-board pattern). The 15-inch spacing was satisfactory; 9 inches was too close (smoked); and 27 inches showed no significant improvement over 15 inches.

These positive results were encouraging and permitted sizing an experimental stack with a fair degree of confidence. The chief purpose of the stack is, of course, to obscure the flame.

CONFINED TESTS

Stack Construction—Two stacks were tested: one was 3 feet in diameter, the other 6 feet. Both stacks were 32 feet high and mounted 5 feet off the ground. They were constructed of ⅛-inch sheet steel. The 5-foot space below the bottom of the stack proved to be adequate to admit an excess of combustion air.

In general, the stack lengthens the flame and, by enhancing draft, tends to produce less stable flames. However, it reduces the tendency of wind to blow the flames out or to cause smoke. The burner was constructed from standard pipe fittings and was assembled essentially along the geometric pattern described later for the commercial unit.

Flameholder Development—It was immediately apparent that unless the burner were 2 feet or more below the stack, the stack draft would lift the flame off the burner and put it out. Standard 3½-inch diameter flanges mounted on the ends of the jets were inadequate as shields. Although they tended to prevent blowout when the burner was in the stack, the flames were quenched when the burner was located in the preferable position below the stack. Satisfactory flameholding and initial propagation of flame from one jet to another were finally achieved by installing horizontal pipes across the burner a short distance (0.5 inches to 1.0 inches) above the ports. End plates on these "flameholders" minimized the effect of wind on the end jets. This method of flameholding was used in all subsequent experiments.

Position of Burner—On both stacks, it was found desirable to place the burner below, rather than within, the stack. Placing the burner below the stack increased both the maximum capacity and the *turndown ratio* of the flare. (*Turndown ratio* is the ratio of maximum to minimum satisfactory flaring rate.)

With the 6-foot stack, turndown ratio was about 2 when the burner ports were 6 inches *above* the bottom of the stack. When the burner was placed 6.5 inches *below* the stack, turndown ratio improved to 10.

Flaring Rate—Up to 140,000 scf per day was burned in the 3-foot stack without flame showing at the top. In the 6-foot stack, a similar burner produced a flame 25 feet long at 600,000 scf per day (2.21 million British thermal units per hour per square foot of stack cross-section).

On the basis of stack cross-sectional area, these two rates are essentially equal. It appears, then, that the limiting gas rate per unit area is not affected by stack diameter.

Jet Diameter—Three combinations were tried:

1. One-half-inch jets with one-half-inch flameholders.
2. One-inch jets with one-half-inch flameholders.
3. One-inch jets with one-inch flameholders.

The third combination was best.

Combustion—Flue-gas samples taken at the top of the 6-foot diameter stack indicated that combustion is quite complete. Although there was some nonuniformity of composition across the stack, the analyses showed an average of 165 percent excess air.

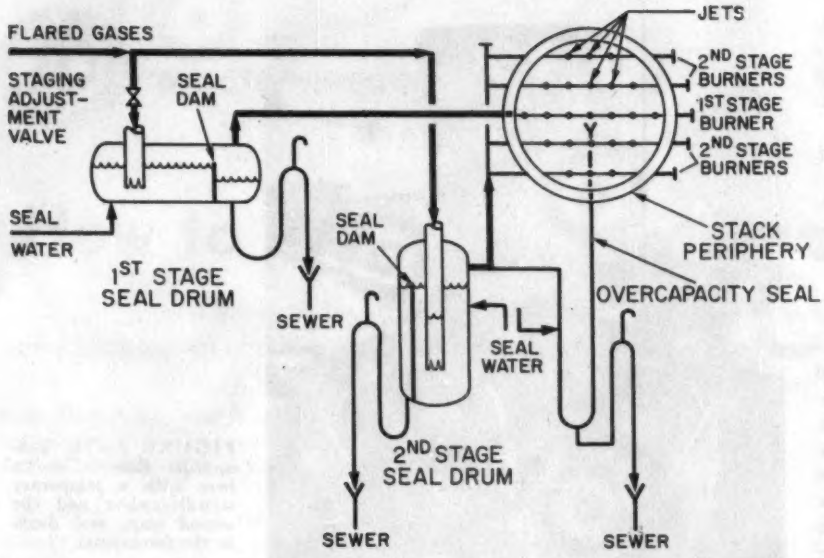
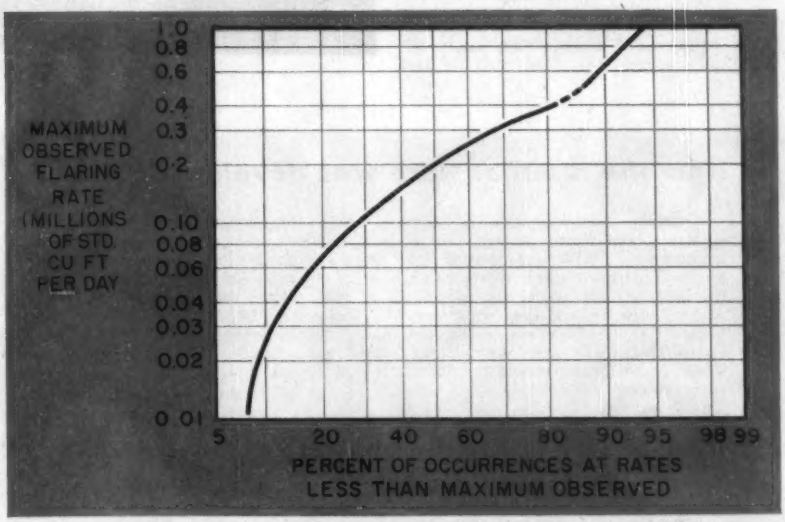


FIGURE 3—This schematic layout (left) of the multijet flare shows the two stages for blowdown control. Notice how the seal dams prevent burner back pressure from varying the seal level.

FIGURE 4—This record (below) of flaring rates shows that a flare sized for 0.2 million scf per day would handle 50 percent of the flaring and one sized for 1.0 million scf per day would handle 95 percent of the flaring.



tank heating, the use of steam injection becomes more attractive.

The cost of a ground flare with water injection is considerably less than that of an elevated flare with independent steam supply. But the ground flare with water injection only eliminates smoke, not visible flame. Because the installation cost of the multijet is essentially the same as that of a ground flare, the multijet becomes the first choice.

TABLE 1—Typical Flare Costs

Type of Flare	Onsite	Offsite	Total
Elevated, No Steam....	$ 66,000	$ 3,000	$ 69,000
Elevated, With Steam...	66,000	225,000	291,000
Ground, With Water....	102,000	44,000	146,000
Multijet.....	145,000	3,000	148,000

Basis: 12 Million Std. Cu. Ft./Day, Mol. Wt. = 40

DESIGN CRITERIA

Process. Figure 3 is a simplified flow diagram for a typical multijet. The flare uses to burners; a small burner handles normal leakage and small blows, while both burners are active at higher flaring rates. This "staging" is controlled by two water-seal drums set to release at different pressure levels.

A third emergency release is provided in the center of the stack, bypassing the multijet burners. The

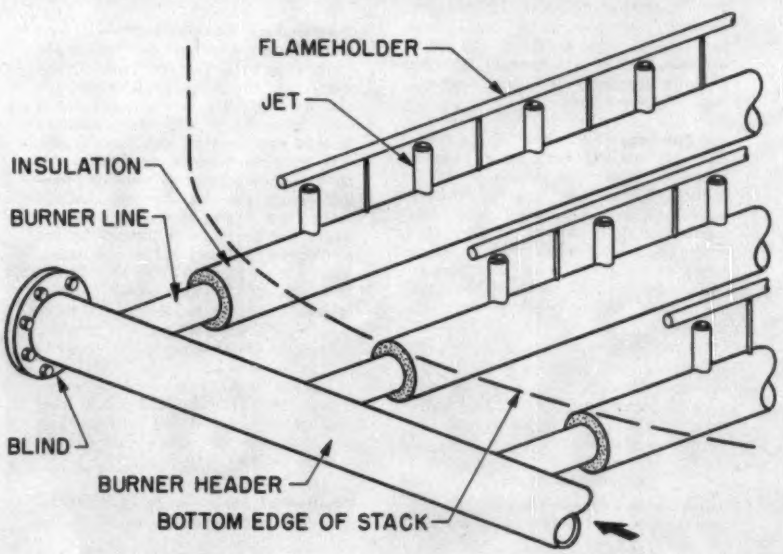


FIGURE 5—Burner assembly showing stagger jets and insulation to protect burner lines from flame impingement.

water seal to this release will blow at flaring rates higher than the design capacity of the flare. When the overcapacity seal has been blown, the flare is, of course, both luminous and smoky. But the unit is usually sized so that an overcapacity blow would be a rare occurrence. The overcapacity line may also discharge to an elevated flare rather than to the center of the multijet stack.

Similar staging could be accomplished with automatic valves or back-pressure regulators. However, our practice is to avoid using automatic instrumentation in safety equipment. The extra price paid for the drums is more than offset by their reliability and ease of maintenance.

The staging system is balanced by adjusting the hand-controlled butterfly valve leading to the first-stage drum. After its initial setting, this valve is locked into position.

Basis for Sizing Equipment. The most difficult task is to estimate the optimum design capacity of the flare. It is easy enough to determine the maximum possible release from certain groups of processing units, but this maximum release would usually occur so rarely that it would not be economical to size the flare on this basis.

Figure 4 shows a record of the incidence of flaring from a certain group of units over a year's time. The maximum flaring rate from these units is not shown on the graph, but on several occasions it approached 15 to 20 million scf per day. However, the graph shows that a flare sized for 0.2 million scf per day would handle 50 percent of the flaring, and one sized for 1.0 million would handle 95 percent of the flaring. When data such as these are available, it is easy enough to make a decision. A flare for this group of units would be sized for 1.0 million scf per day, having an overcapacity line (or elevated flare) sized for 20 million scf per day.

Stack Dimensions. The inside diameter of the stack is based on the rate of heat release at design capacity. Currently, 0.535 square feet of stack cross-sectional area per million Btu. per hour is used. As an equation,

$$D = 0.828Q^{0.5} \qquad (1)$$

Where:

D = stack inside diameter, feet.
Q = heat release, millions of British thermal units per hour (based on high heating value).

The vertical length of the stack, i.e., vertical length of the stack vs. height of the top of the stack above-ground, is independent of the diameter and is usually made 32 feet. The bottom of the stack is above grade; the minimum clearance between grade and the bottom of the stack is either one-fourth of the stack inside diameter or 6 feet, whichever is greater.

The steel shell of the stack is lined for its entire length with 4 inches to 6 inches of refractory and insulating material.

Burner Stages. As discussed previously, the multijet burner has a turndown ratio of approximately 10:1. A two-stage burner will give a maximum turndown ratio of 100:1—which is adequate for most situations. When designing for two stages, let the first stage handle approximately 20 percent of the total maximum load. Although this reduces the over-all turndown ratio to approximately 50:1, it will permit a reasonably large flaring rate without blowing both water seals. It also provides a large overlap between the maximum burning rate of the first stage and the minimum rate of the second stage. This is desirable for smooth operation.

Number of Burner Jets. The jet nozzles are made from standard 1-inch pipe; each nozzle is 5 inches long. The jets discharge vertically from subheaders, or burner lines, which run horizontally across the bottom of the stack. The burner lines are connected just outside the stack to a large header. This arrangement is shown in Figure 5.

For design rates up to 12,000,000 scf per day, the burner lines are usually specified as 6-inch pipe. The common header on the second-stage burner would be approximately 18-inch pipe.

The number of jets is based on gas velocity. For 1-inch standard pipe, the recommended velocity permits a flow rate of 61,200 scf per day per jet. Expressed as an equation,

$$N = 16.4\,V \qquad (2)$$

Where:

N = number of jets.
V = flare design capacity, millions of standard cubic feet per day (for a flare system, standard cubic feet is almost always equivalent to actual cubic feet).

The jets are on a square or rectangular layout with a pitch of 18 inches to 24 inches. A first estimate of the

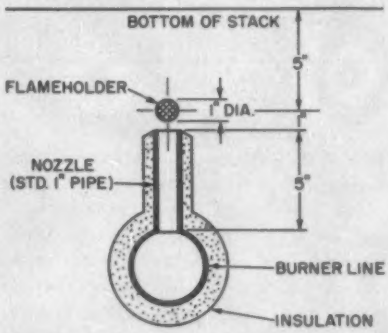


FIGURE 6—These are the critical dimensions for the flameholder, nozzle, and the height of stack above nozzle tip.

required pitch can be obtained from the following:

$$P_s = \frac{10\,D}{N^{0.5}} \text{ (for square layout)} \qquad (3)$$

$$P_s = \frac{100\,D^2}{N\,C} \text{ (for rectangular layout)} \qquad (4)$$

Where:

P_s = jet pitch, *inches*.
D = stack inside diameter, *feet*.
N = number of jets.
C = distance between center lines of burner lines, *inches*.

No jets should be placed closer than 12 inches to the inside of the stack. For gases with low heating values, it is usually preferable to decrease the jet pitch to less than 18 inches in order to avoid an increase in the stack inside diameter. It is preferable to keep the pitch above 15 inches.

Flameholders. The flameholders actually are the most important feature of the flare. They are solid, 1-inch diameter rods of refractory material running horizontally above each burner line. The rod is positioned directly over the jet nozzles, with the

About the Speaker

Paul D. Miller, Jr., is a design engineer with Esso Research and Engineering Co. in Linden, N. J. He has been with the company since 1953. Miller has worked with process design problems which are related to both current and developmental types of plants. He has B.Ch.E. and M.S. degrees from North Carolina State College.

bottom of the rod ½ inch above the tips of the nozzles. The rods provide a surface at which burning can take place, preventing the flame from riding up to the top of the stack. The flameholders also promote better mixing of air and gas by the additional turbulence which they cause above the jets.

The entire burner assembly—except for the flameholders—should be insulated to withstand direct flame impingement.

Critical Dimensions. The position of the flameholders and burner lines relative to the bottom of the stack is critical for proper operation. These dimensions are shown in Figure 6.

So far, all of our multijet designs have included provisions for field adjustment (± 2 inches) of the distance between the top of the burner lines and the bottom of the stack. This is done with variable-length pipe hangers and a relatively long main header.

The burner lines should all lie in an absolutely horizontal plane below the stack. The main headers are sloped back to the seal drums to provide drainage.

Pilot Burner. One or two pilot burners are provided at each end of the first-stage burner line. These burners are recessed into the wall of the stack and directed over the nearest jet. Most designs include both an oil-fired and a gas-fired pilot at one end of the burner line to insure an active pilot at all times.

Windbreaker. The recommended windbreaker is an octagonal louvered fence placed approximately 8 feet from the stack, and extending to a height approximately 2 feet above the bottom of the stack. The construction is somewhat like a Venetian blind. This avoids line-of-sight vision to the bottom of the stack, while permitting the entrance of combustion air. The slats are approximately 6 inches wide with at least 2 inches of overlap. They are sloped at a 45-degree angle to direct the flow of air downward on the inside of the enclosure. As a safety precaution, there are four access doors in the windbreaker.

The stack and the windbreaker stand over a slightly concave, concrete pad. Drainage is provided from the center of the pad to a sealed catch basin.

Seal Drums. The seal drums provide protection against flashback into the blowdown lines. They also make it possible to set up a simple staging system for the burners.

The drums are sized on two criteria:

1. The water holdup should be sufficient to provide a 10-foot slug of water in the inlet line to the drum in the event of an explosion downstream of the drum.
2. To avoid excessive entrainment, the vapor velocity in the drum should not exceed that given by the following equation:

$$v = 0.267\left(\frac{d_L - d_g}{d_g}\right)^{0.5} \qquad (5)$$

Where:

v = allowable vapor velocity, feet per second.
d_L = density of entrained liquid, pounds per cubic foot.
d_g = density of vapor, pounds per cubic foot.

A seal dam is provided in each drum to prevent the burner back pressure from varying the seal level. This is shown in Figure 3. The seal loops from the drum to the sewer should provide a seal depth of at least 10 feet. Each drum is provided with a seal water rate of approximately 20 gpm.

The submerged ends of the inlet lines to the drums are notched to prevent cyclic release of the gas which accumulates from normal leakage.

Originally presented before the API Division of Refining Meeting, Los Angeles, May 14, 1958. # #

More on Waste Disposal

Pollution Control at Ferndale: Pollution control at the Ferndale, Wash., refinery of General Petroleum Corporation involves the design and operation of the various processes used to control liquid and air-borne wastes. The methods of water disposal chosen were dictated by stringent requirements set up by a state agency on the quality of effluent released into all state waters. Georgia Strait, on which the refinery is located, is used for sport fishing, commercial fishing, oyster culture, and recreation. It is also the main artery for the migration of salmon to and from the Fraser River in Canada.

The refinery has six separate and distinct sewer systems to accommodate the various types of wastes. These systems are: oily process waste, sanitary waste, phenolic process waste, normal storm drainage, emergency storm drainage, and ships' ballast discharge. Wastes handled in the first three of these systems are subjected to biological oxidation to reduce phenols. Pretreatment of the various waste streams is essential in order to provide a uniform feed to final biological-oxidation waste-water treating equipment.

Every opportunity is taken to regenerate alkaline solutions used in treating petroleum products, thus enabling reuse of these solutions and providing a further reduction in the load to the biological-oxidation units. When strong spent caustic and potassium cresylate treating solutions are no longer effective, they are enriched with the addition of excess hydrogen sulfide or cresylic acids, respectively, prior to sale. The use of stripped hydrogen sulfide gases in the spent caustic sulfiding tower has helped to reduce the quantity of this gas that has to be burned and, consequently, has reduced the emission of sulfur dioxide to the atmosphere.

Floating-roof tanks are used extensively at the refinery to conserve hydrocarbons and reduce emissions to the atmosphere.

("Pollution Control at Ferndale, Wash.," E. K. Daniels, J. R. Lutz, and L. A. Castler, General Petroleum Corp., Los Angeles.)

How Shell Treats Refinery Wastes

By adequate planning and using known methods in a novel arrangement, Shell has solved the waste disposal problem at its Anacortes refinery.

G. J. Reno and E. D. Neumann
Shell Oil Company, Anacortes, Wash.
L. C. Burroughs, Shell Oil Company
New York City

IN PLANNING for a refinery in the Puget Sound area, which has long been a sports and commercial fishing paradise, Shell Oil Company made maximum efforts to insure that no harmful effects to wildlife resources and adjoining property would result from operation of the refinery. Final choice of the site near Anacortes, Wash., necessitated very strict control of waste water quality to protect clams, crabs, and rich oyster beds in the refinery vicinity.

After consultation with experts in the waste water treatment field and the Washington State Department of Fisheries and Pollution Control Commission, Shell chose to treat its waste water using a novel arrangement of known methods including sulfide stripping, oil-water separation, chemical flocculation, and biological treatment.

Figure 1 shows the treating area including a two-channel API-type oil-water separator, two primary clarifiers, a biological trickling filter, an activated sludge unit with two clarifiers, and large detention basins for treated water. Auxiliary equipment for sludge disposal includes a reservoir, a thickener, two rotary vacuum filters, and a kiln. The building houses the rotary vacuum filters, chemical feeders, switchgear, and laboratory-office. Also shown are the storm flume; the chemical neutraliz-

FIGURE 1—Waste treatment facilities at Shell Oil Company's Anacortes refinery.

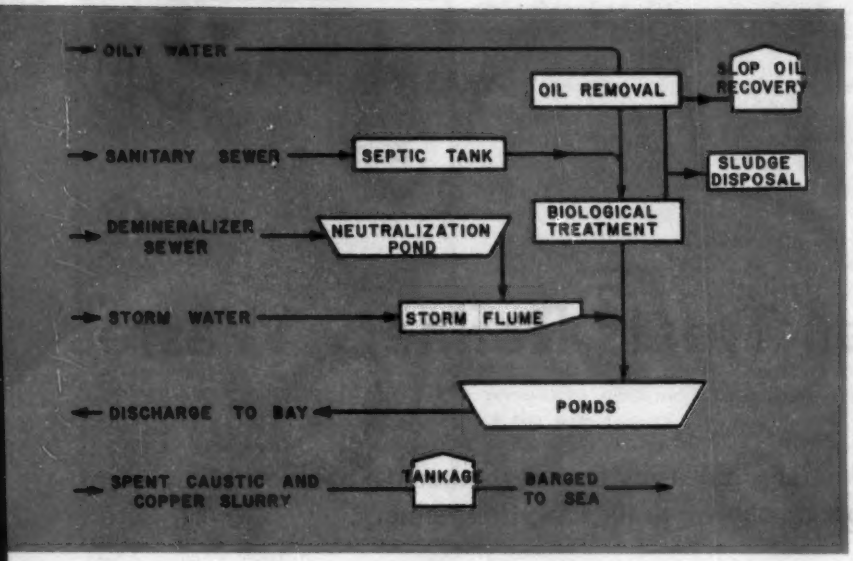


FIGURE 2—Here's the flow pattern for four waste water streams and tankage for collecting spent caustic and copper slurry.

ing basin; and tankage for slop oil, ballast, and spent chemicals.

WASTE STREAMS

Four separate sewer systems deliver waste water to the treatment facility as shown in Figure 2.

1. Oily Water Sewer. The oily water sewer handles all wash and rain water from the process areas, ballast water, drainage from the laboratory and garage, and stripped sour waters. Two steam stripping units remove hydrogen sulfide and ammonia from sour process waters, thereby eliminating a personnel hazard and objectionable odors from the sewer. Additional benefits of these strippers are reduced load on the biological section of the treating plant, heat release, and increase in pH of the oily water stream. As shown in Figure 2, this stream undergoes oil removal, chemical flocculation, and biological treatment prior to disposal.

2. Sanitary Sewer. All sanitary wastes in the refinery flow to a large septic tank located in the water treating area where bacteria digest the solids. The effluent from the septic tank joins the oily water stream prior to biological treatment.

3. Demineralizer Sewer. This chemical sewer receives dilute acid and dilute caustic wash waters from the regeneration of ion exchange demineralizers used to soften boiler feed water. These alternate acid and caustic washes are ponded with the intent of neutralization. Although neutralization is incomplete due to lack of mixing in this pond, no effect on the total effluent from the refinery results because the main treated waste water stream is highly buffered.

4. Storm Sewer. Rain water runoff from all parts of the refinery which are not normally subject to oil spills is collected in a "storm sewer" which empties into an open storm flume in the waste water treating area. The storm flume is equipped with a slotted pipe oil skimmer and a trash bar screen.

All waters from these four major sewers are ultimately combined in detention basins from which they are pumped to the end of the wharf 3,000 feet into the waters of Puget Sound for disposal.

The treating area is also equipped with disposal facilities, as follows:

1. Spent caustic and copper slurry are collected in tankage at the effluent plant for barging to sea.

2. Slop oil is dewatered prior to returning to the refinery for reprocessing.

3. Sludges from the oil-water separator, the flocculators, and the biological section are thickened, filtered, and incinerated.

OIL REMOVAL

A schematic flow diagram of the oil removal section is shown in Figure 3. The oily water sewer enters the two-channel API-type oil-water separator, where floatable oils are skimmed and sediments removed to a sludge handling system.

Chemicals, controlled by a flow controller, are added to the skimmed water leaving the oil-water separator. These chemicals form a floc in the center section of the primary clarifiers, absorb solids and oils, and settle to the bottom as a sludge which is removed to the sludge handling system. Clarified water flows from the periphery of the clarifiers to the biotreatment section for removal of the biochemical oxygen demand (BOD) including phenols and sulfides.

The two-channel API-type oil-water separator is shown in Figure 4. Water passes through an inlet distributor to the forebays which are 30 feet long by 18 feet wide; vary in depth from 6 feet, 3 inches to 6 feet, 2 inches; and are provided with slotted pipe oil skimmers and bottom. scrapers. The forebays are covered to prevent loss by vaporization of volatile components of separated slop oil.

The water passes under a curtain wall to the afterbays which are 100 feet long and 18 feet wide; vary in depth from 6 feet, 2 inches to 5 feet, 11 inches; and are also provided with slotted pipe skimmers and slight scrapers for sludge removal.

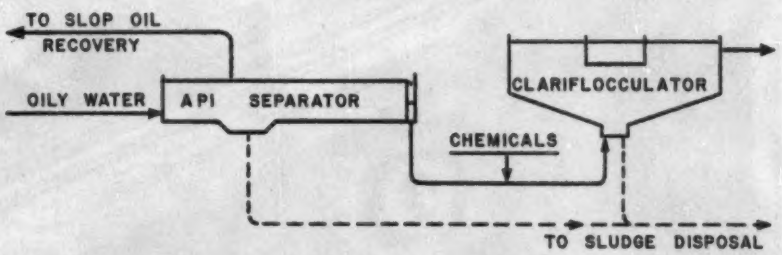


FIGURE 3—API separator, chemical treatment and flocculation are used for oil removal.

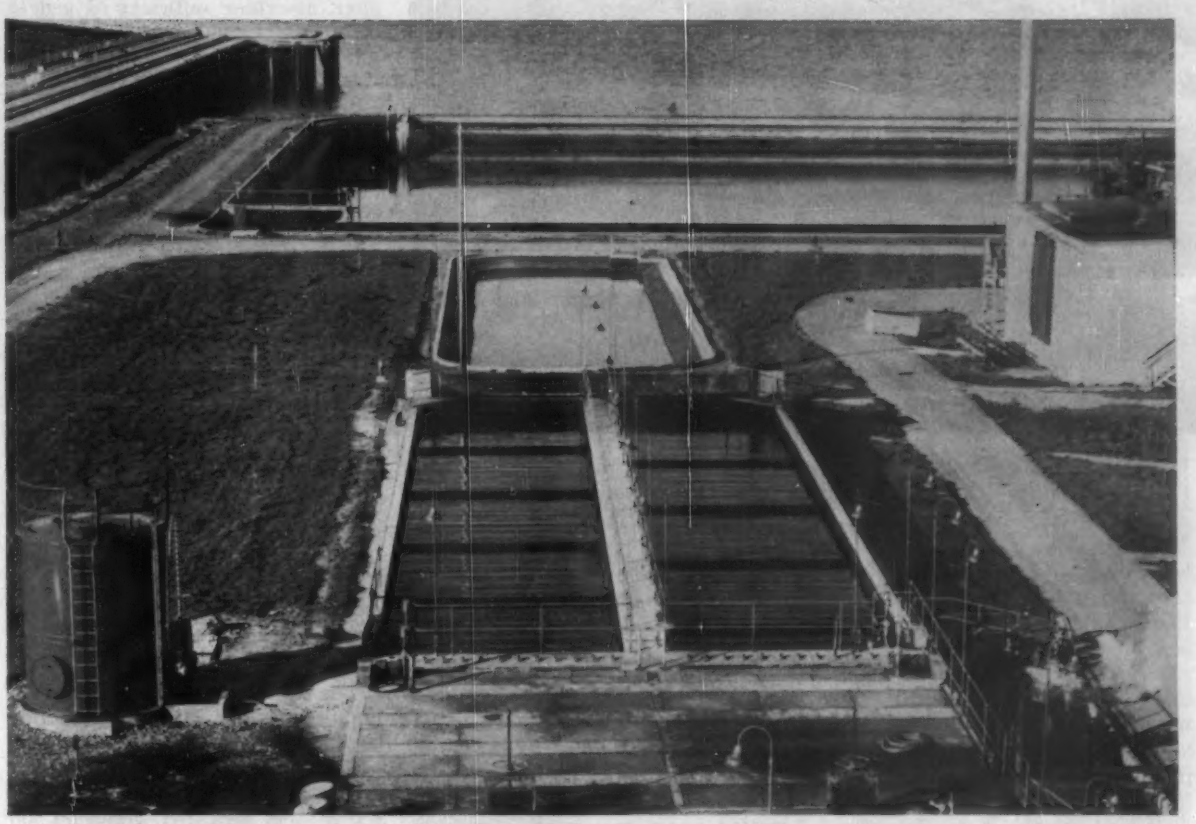


FIGURE 4—These two-channel API-type oil-water separators have covered forebays to prevent loss of volatile components.

The separator is designed for a throughput of 2,000 gpm of water. Skimmed oil is collected in a sump. Water which is skimmed with the oil is automatically returned to the separator by a pump controlled by an interface liquid level controller. Periodically, skimmed oil is removed to a 1,000-barrel de-emulsifying tank held at 150 F. for settling.

After a time, oil having less than 2.5 percent water and sediment is transferred to a 10,000-barrel slop oil collection tank where further settling occurs. Oil containing more than 2.5 percent water and sediment is transferred to another 1,000-barrel tank for further treatment. The contents of the second 1,000-barrel tank are checked periodically to determine if settling, filtering, or use of de-emulsifying chemicals will be required to complete the cleanup job.

Filtering is carried out whenever solids content is excessive. This procedure is necessary approximately once every two months. The use of de-emulsifying chemicals is rarely necessary. Slop oil returned to the refinery for reprocessing has a water and sediment content of 0.1 to 0.2 percent by volume.

Best operation of the oil-water separator is achieved when sediment is continuously removed to the sludge system and continuous skimming of the forebays is carried out. Normally, well over 90 percent of the slop oil separates in the covered forebays. When this is not done, oil content of the effluent from the separator increases, although additional skimming is carried out near the exit of the afterbays.

Addition of flocculation chemicals was originally based on the alkalinity of water leaving the oil-water separator, as in standard water treating practice. Although flocculation was good for several weeks after the refinery was placed in operation, it soon began to deteriorate. Laboratory tests showed then an entirely new alkalinity range was necessary to give satisfactory flocculation. After a time, it became obvious that each change in alkalinity range had resulted in the return to a pH value of 8.7 to achieve best flocculation. Subsequently, pH control has been used to control addition of floc-forming chemicals. The pH of the separator effluent is adjusted to 8.7 by addition of lime and/or automatic addition of sulfuric acid, and dosages of alum and activated silica based on laboratory flocculation tests are added to the water to produce a floc.

Two interferences were encoun-

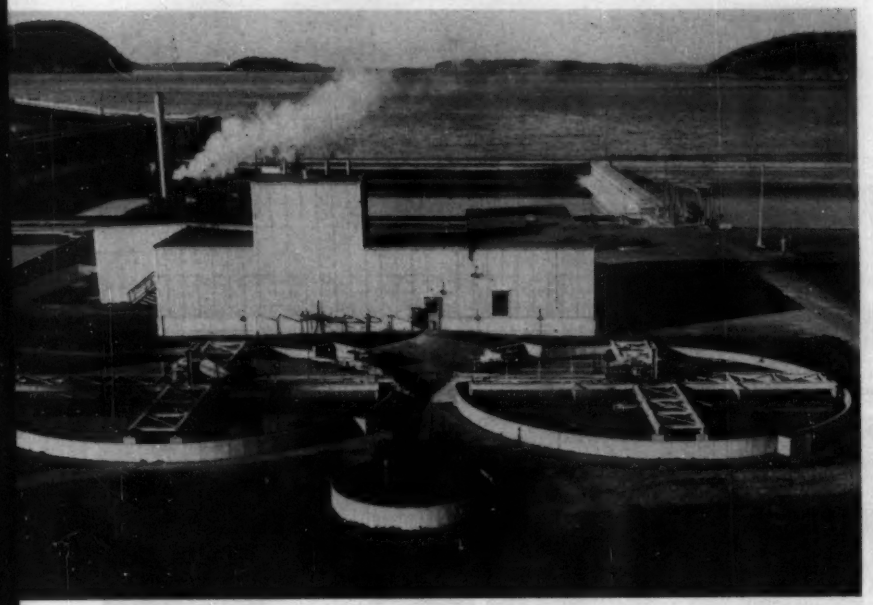


FIGURE 5—The two primary flocculators are 60 feet in diameter. In the foreground is the sludge reservoir and the treatment building and lab in the background.

tered in striving for optimum flocculation. Diammonium phosphate added to the water as a nutrient for the activated sludge was found to interfere with the formation of a good floc. Consequently, it was necessary to add this chemical after the flocculation step. Addition of ferrous sulfate to effect precipitation of sulfides prior to biological treatment also interfered with the formation of floc. Experience demonstrated that the biological treatment section was better able to cope with the additional sulfide load than with the floc carry-over caused by the addition of ferrous sulfate.

The primary flocculators (shown in Figure 5) are concrete tanks 60 feet in diameter, 10 feet deep at the outer edge, and 15 feet deep at the center. The center flocculation section is 31 feet in diameter and 9 feet deep. Bottom scrapers move settled floc to the outlet. A surface skimmer is provided for recovery of floatable oils. The flocculators are designed to handle 1,500 gpm each.

The removal of oil at various stages of treatment is outlined in Table 1.

TABLE 1—Oil Removal Summary

	Oil in Effluent (Parts Per Million)
Oil-water separator	80 to 115
Primary clarifier	25 to 45
Biological treatment	7

Notice that the oil-water separator has produced an effluent containing 80 ppm to 115 ppm total oils.[1] Since the separator is generously sized for the flow handled, it is expected that more complete oil removal will be attained in future operation. Flocculation reduces the oil content to 25 ppm to 45 ppm. Additional oil removal by the biological section results in a treated water containing 7 ppm of oils, well within the required maximum of 15 ppm.

BIOLOGICAL TREATMENT

A schematic flow diagram of the biological treatment section is shown in Figure 6. Clarified oily water plus effluent from the septic tank is pumped over the trickling filter at a rate of 3,000 gpm, including recycle of the trickling filter effluent as necessary. The water-driven distributor sprays the water over the trickling filter, absorbing sufficient oxygen to satisfy the aerobic bacteria which reside on the filter.

The water leaving the trickling filter enters the activated sludge section, consisting of a four-bay aeration basin, where it is intimately contacted with activated sludge and air and then proceeds to two final clarifiers which remove the activated sludge prior to ponding of the treated water. Activated sludge is pumped from the clarifiers, and is either returned to the aeration basin to maintain the culture or removed to the sludge handling system for disposal.

The trickling filter is shown in Figure 7. The trickling filter consists of a rock pile, 140 feet in diameter and 10 feet deep, surmounted by a water-driven distributor which is designed to handle 3,000 gpm of water. The trickling filter was expected to reduce the BOD content of 2,000 gpm of water from 400 ppm, of which 40 ppm is phenols, to 200 ppm.

The aeration basin is shown in Figure 8 and consists of four concrete bays 80 feet long, 20 feet wide, and 14 feet deep. They are equipped with 64 jet nozzles for contacting air, water, and activated sludge; 1,500 gpm of water plus activated sludge is pumped from the outlet of the aeration basin to the jet nozzles for contacting with from 1,000 to 3,000 cubic feet per minute of air.

The activated sludge section clarifiers (shown in Figure 9) are con-

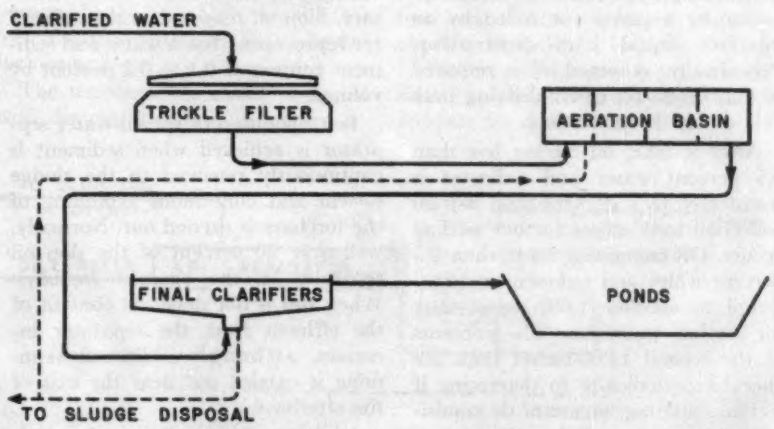


FIGURE 6—Biological treatment flow diagram showing sluge recirculation to the aeration basin.

crete tanks 60 feet in diameter, 13 feet deep at the center, and 10 feet deep at the outer edge. They are designed to handle 2,000 gpm of effluent, including a 500 gpm load of activated sludge. Pumps are provided to return the activated sludge to the aeration basin or dispose of it to the sludge reservoir controlled by a time cycle controller.

Data showing the results obtained in the biotreatment section are presented in Table 2 in terms of concentration in effluent from each unit. The load on the biotreatment section is 175 ppm expressed as five-day biochemical oxygen demand.[2] The trickling filter removes 85 percent of the biochemical oxygen demand, 98 percent of the phenol,[3] and all of the sulfides.[4] Most of the balance of the biochemical oxygen demand, including phenols, is removed by the aeration basin. Water leaves the aeration basin with a dissolved oxygen content of approximately 2 ppm to 5 ppm, increasing to 7.5 ppm during ponding. Further reduction of biochemical oxygen demand and phenols during ponding cannot be explained by dilution with storm waters.

In all, the plant removes 96 percent of the biochemical oxygen demand in the feed, including 99.5 percent of the phenols and 100 percent of the sulfides, and establishes an oxygen residual[5] of 7.5 ppm.

DETENTION BASINS AND DISPOSAL

The detention basins (shown in Figure 10) are two gunite-lined basins of 6 million and 5½ million gallons capacity. The storm flume adjacent to the smaller basin has a capacity of 0.5 million gallons. Facilities provide a choice of several flow patterns to the basins. Water in these basins may be returned to the plant for further treatment, if necessary.

The basin water passes through a hay filter, and is then pumped to the wharf some 3,000 feet offshore where it is injected into the bay 34 feet below low mean tide during tide runs. This method of disposal insures rapid dispersion.

TABLE 2—Biotreatment Summary
(Flow of 1,200 Gal Per Min)

	Concentration in Effluent (Parts Per Million)			
	Biochemical Oxygen Demand	Phenols	Sulfides	Dissolved Oxygen
Primary clarifier	175	30	13	....
Trickling filter	25	0.6	NIL	....
Aeration basin	10	0.2	NIL	2 to 5
Retention pond	8	0.15	NIL	7.5
Total removal, percent	96	99.5	100	....

PREPARATION OF ACTIVATED SLUDGE

Development of the activated sludge used for treatment of the refinery waste water is an interesting story. Prior to beginning of plant operation, activated sludge was obtained from a nearby municipal sewage disposal plant. This sludge was fed a diet of chemical fertilizers and sulfate waste liquor from a nearby pulp mill to build up a large healthy population.

Adaptation of the culture to phenol consumption was then accomplished by adding a small continuous flow of cresylic acid. First additions of cresylic acid caused a heavy death rate among the bacteria; however, in due course, a strain of bacteria which were capable of actually removing phenols was selectively bred. Development of these bacteria was encouraged by gradually increasing the amount of cresylic acid going to the culture until a phenol concentration up to 40 ppm could be accommodated.

When the catalytic cracking unit was brought onstream, the activated sludge was switched from artificial feeding to the natural phenolic content of the refinery process waste waters without difficulty. Activated sludge which is used for treating of refinery waste has only a slight odor compared to activated sludge from a municipal sewage treating plant.

CONTROL OF ACTIVATED SLUDGE

The major control over the operation of the aeration basin is the control of the population of bacteria.

FIGURE 7—This trickling filter, 140 feet in diameter, can handle 3,000 gpm of waste water.

Population is measured by a suspended solids analysis of water in the aeration basin and controlled by destruction of a portion of the activated sludge recovered in the final clarifiers.

Operating experience with a feed containing 0.5 ppm to 3.0 ppm of phenols has led to the relationship shown in Figure 11 between phenol concentration in the aeration basin effluent and suspended solids content of the aeration basin. As a result of this relationship, our plant is operated at concentration of activated sludge in the range of 300 ppm to 500 ppm.

BIOTREATMENT OPERATING EXPERIENCES

The reaction of activated sludge to sudden changes in its environment

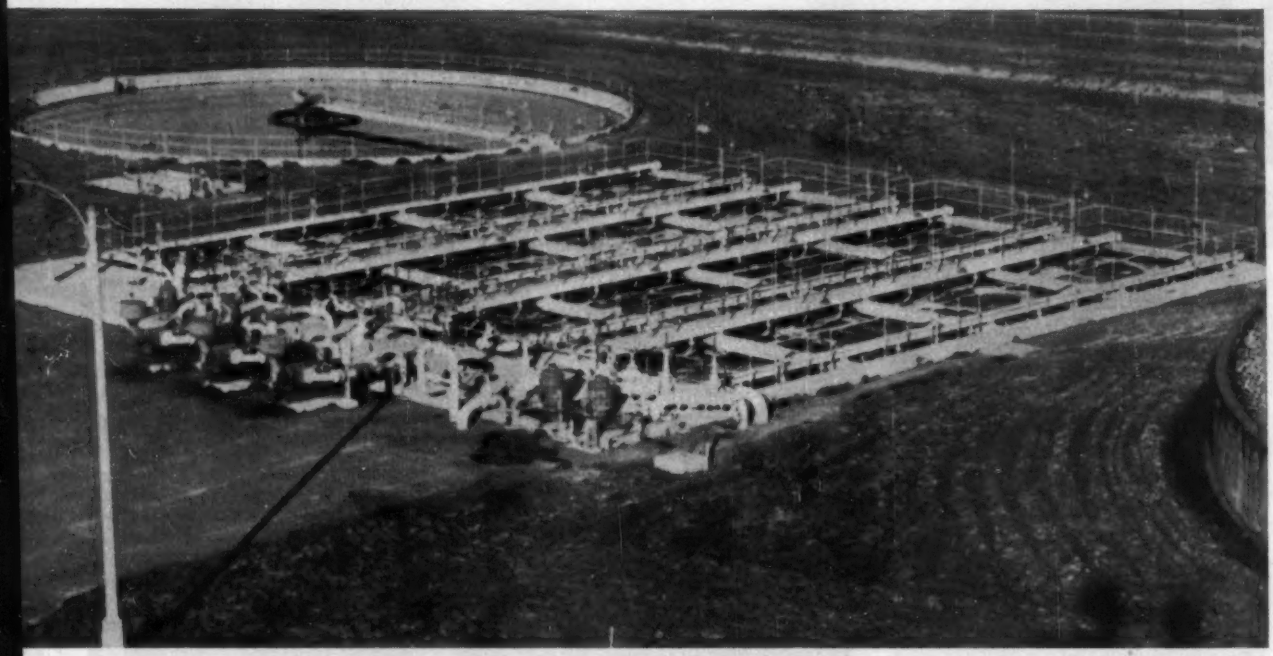


FIGURE 8—This four-bay activated sludge aeration basin contacts water and sludge with 1,000 to 3,000 cubic feet per minute of air.

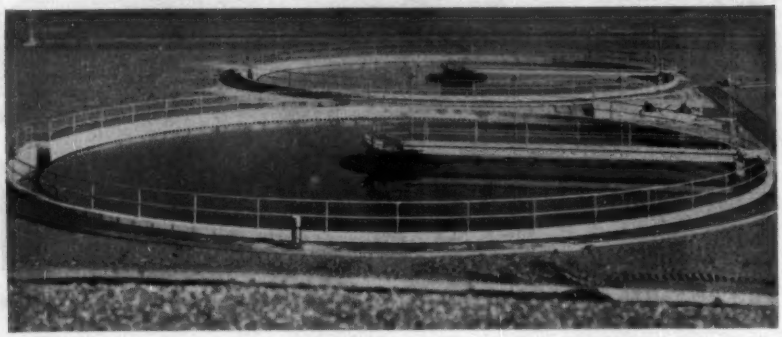


FIGURE 9—Two activated sludge clarifiers are designed to handle 2,000 gpm of effluent.

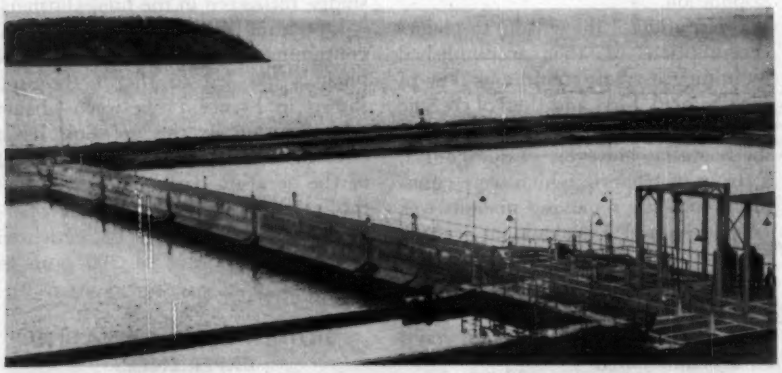


FIGURE 10—Two detention basins have capacities of 6 million and 5½ million gallons. The storm flume has a capacity of 0.5 million gallons.

and its rate of recovery is of major interest to the operator or potential operator of a plant. The effect of a small increase in operating temperature and of shock loadings of phenols and sulfides can be demonstrated from operating experience to date.

The effect of a small change in temperature on the biological treating section is shown in Table 3. Phenol removal was slightly improved when the temperature was increased from 65 F. to 70 F. These data are not conclusive, however, because changes of this magnitude are often observed over a similar period of time without explanation. However, increased activity of the activated sludge is clearly shown inasmuch as the save-waste cycle had to be changed from 8 save (return to aeration basin) 2 waste (to sludge disposal) to 6 save 2 waste to approach the same concentration of activated sludge.

In Table 4, the effect of a shock loading of phenols is demonstrated. The excellent condition of the plant on the day (D—1) prior to the shock loading should be noted. As a result of the inadvertent dumping of spent caustic containing alkyl phenols into the oily water sewer, the phenol concentration of the oily water sewer was increased tenfold for a 24-hour period (D+O). The trickling filter took the brunt of the shock and lost

a large measure of its effectiveness. The aeration basin, however, improved in effectiveness. The presence of the overload was quickly indicated to the operators by the disappearance of dissolved oxygen in the effluent from both the trickling filter and aeration basin. Increased growth rate of the biosludge was also observed.

Early discovery of the shock loading and its effect on the biological treating section allowed time to dispose of all of the water in the detention ponds while water quality was within disposal limits. This technique allowed time for retreatment of water which obviously was leaving the treatment section with high phenol content. During the next several days, all effluent from the plant was recycled back to the biological treatment section for retreatment.

At the end of the third day, the trickling filter had almost fully recovered. It is interesting to note, however, that the aeration basin was much less able to adapt to a reduction of phenol content of feed to the basin. It is also interesting to note that the phenol concentration of the water in the detention basins exceeded the phenol concentration in the biological treatment section effluent at this time.

Complete recovery of the biological treating section occurred after seven days, including return of the detention pond system to less than 0.2 ppm of phenols. As a result of the large capacity of the detention basins, no undertreated water was discharged from the refinery.

The effect of a heavy sulfide loading on the biological treating section is shown in Table 5. Operation of the plant just prior to the high loading of sulfide was not quite as favorable as in the previous example. A fivefold increase in sulfide loading occurred as a result of a shutdown of a sour water stripper. Although the trickling filter was readily able to remove the increased amount of sulfides, its phenol-reducing capacity was substantially decreased. Apparently the activated sludge consumes sulfides in preference to phenols. The aeration basin was able to handle this slight increase in load without effect. After only two days the plant returned to normal.

TABLE 3
Effect of Temperature on Biotreatment

	D+0	D+1	D+2	D+3
Temperature, deg F	65	70	70	70
Phenols, ppm				
Primary clarifier	36	41	36	35
Trickling filter	0.8	0.7	0.6	0.5
Aeration basin	0.25	0.25	0.23	0.23
Dissolved oxygen, ppm				
Trickling filter	5	5	5	5.5
Aeration basin	5	5	4	4
Biosludge				
Concentration	460	580	650	525
Save-waste cycle	8–2	7–2	6–2	6–2

TABLE 4
Effect of Temporary Heavy Phenol Loading on Biotreatment

	D–1	D+0	D+3	D+5	D+7
Phenols, ppm					
Primary clarifier	20	300	20	20	20
Trickling filter	0.5	70	0.8	0.6	0.5
Aeration basin	0.18	2.7	0.6	0.33	0.23
Retention ponds	0.13	0.14	0.96	0.33	0.19
Dissolved oxygen, ppm					
Trickling filter	6.5	NIL	4.5	5	6
Aeration basin	6	NIL	3.5	5	6
Biosludge					
Concentration	500	600	800	550	430
Save-waste cycle	4–2	4–2	3–2	5–2	5–2

TABLE 5—Effect of Heavy Sulfide Loading on Biotreatment

	D–1	D+0	D+2
Sulfides, ppm			
Primary clarifier	20	100	20
Trickling filter	NIL	0.3	NIL
Phenols, ppm			
Primary clarifier	26	26	40
Trickling filter	1.3	3.0	0.75
Aeration basin	0.32	0.31	0.32
Biosludge			
Suspended solids	400	385	360
Save-waste cycle	9–2	7–2	8–2

SLUDGE DISPOSAL

A schematic flow diagram of the sludge handling system is shown in

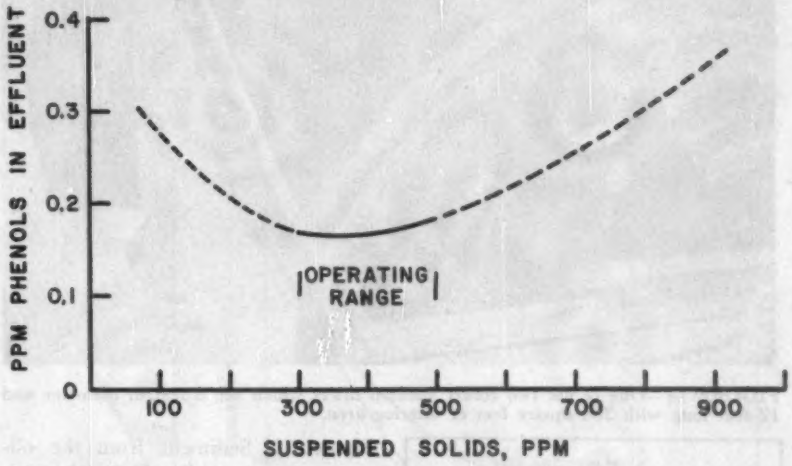


FIGURE 11—From experience, the normal operating range of suspended solids in the aeration basin was best controlled at 300-500 ppm.

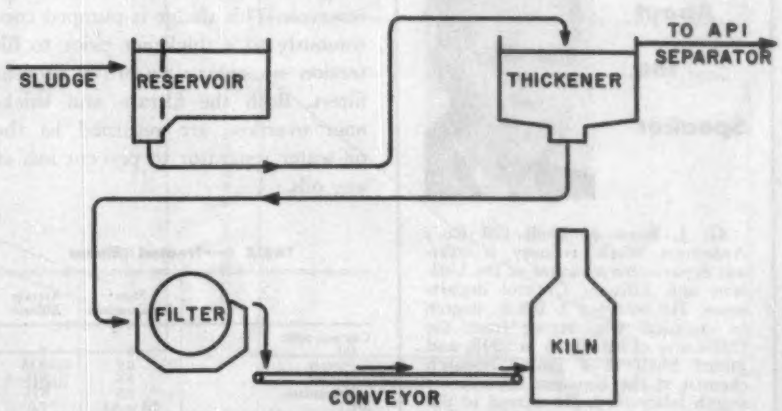


FIGURE 12—Sludge is thickened, filtered and finally burned in a kiln.

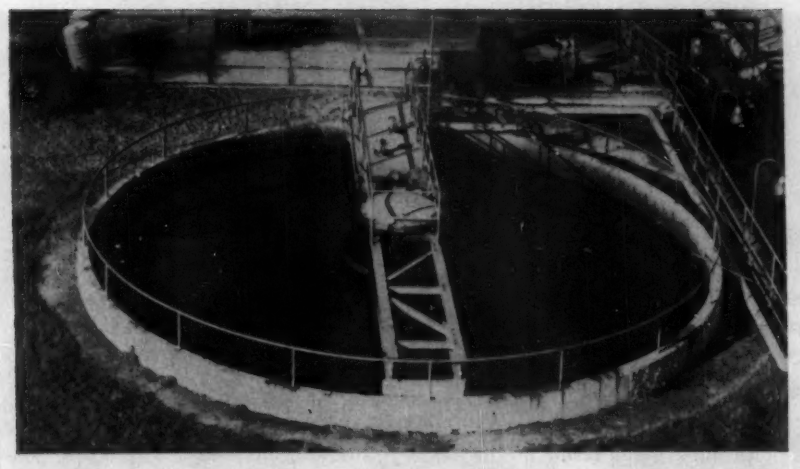


FIGURE 13—The sludge thickener is 30 feet in diameter and is designed from 3 to 6 percent of solids-plus-oil.

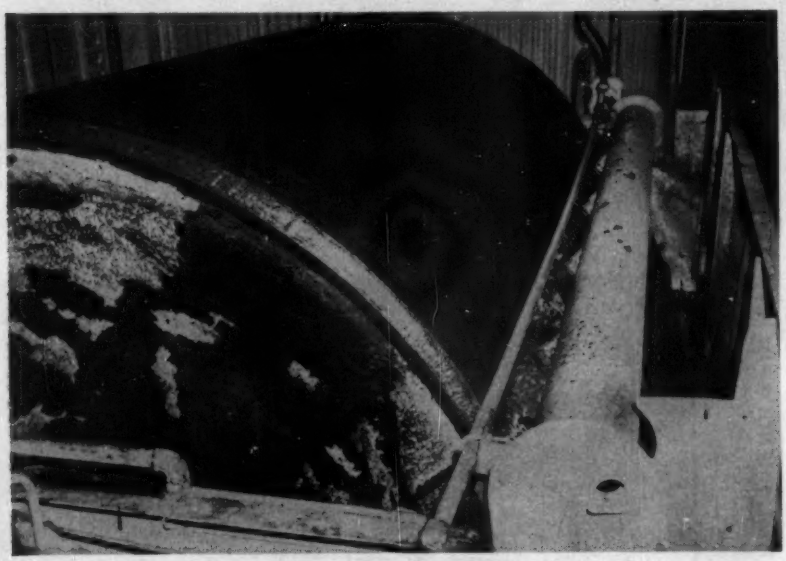


FIGURE 14—One of the two rotary vacuum filters which are 8 feet in diameter and 12 feet long with 300 square feet of filtering area.

About the Speaker

G. J. Reno of Shell Oil Co.'s Anacortes, Wash., refinery, is assistant department manager of the Utilities and Effluent Control department. He received a B.S.E. degree in chemical engineering from the University of Michigan in 1943, and joined Shell as a junior research chemist at the Houston refinery research laboratory. He moved to the Anacortes refinery in 1955.

Figure 12. Sediment from the oil-water separator, floc from the primary clarifiers, and activated biosludge are accumulated in the sludge reservoir. This sludge is pumped continuously to a thickener prior to filtration on rotary vacuum precoat filters. Both the filtrate and thickener overflow are returned to the oil-water separator to prevent loss of any oils.

TABLE 6—Treated Effluent

	State Requirements	Average Effluent
Content, ppm:		
Oil	15	7
Phenols	0.2	0.15
Sulfides	0.5	NIL
Mercaptans	0.5	NIL
pH	6.5 to 8.5	7.0

The reservoir is a concrete tank 20 feet in diameter and 15 feet deep. Two 120 gpm pumps are provided to remove the sludge from the reservoir to the thickener, which is shown in Figure 13. The thickener is 30 feet in diameter, 13 feet deep at the center, and 12 feet at the outer edge; it is designed to concentrate the sludge from 3 percent of solids-plus-oil to 6 percent of solids-plus-oil. Overflow from the thickener is returned to the oil-water separator. Thickened sludge is pumped to the filters by two 60 gpm pumps.

One of the two rotary vacuum precoat filters is shown in Figure 14. The filters are 8 feet in diameter and 12 feet long, having 300 square feet of filtering surface each. They are designed to handle 20 gpm at a solids-plus-oil content of 6 percent or 40 gpm at a solids-plus-oil content of 3 percent. The filtered sludge is conveyed to the gas-fired kiln which has 6 hearths and a total surface of 150 square feet. It is designed to handle 900 pounds per hour of filter cake having a composition of ⅓ filter aid, ⅓ oil, and ⅓ water.

OVER-ALL PLANT PERFORMANCE

In Table 6, the over-all performance of the plant is compared with the Washington state requirements for waste water pumped to the waters of Puget Sound. Oil, sulfides, and mercaptans content are never a problem becausue of the high efficiency of the plant. The plant has successfully reduced the phenols to below the limit of 0.2 ppm set by the state of Washington which averages 0.15 ppm of phenols. Control of the pH of the over-all effluent from the plant by addition of lime is necesary because biological treatment reduces the pH of the treated water to approximately 6.0.

Original presentation was before the American Petroleum Institute, Division of Refining, Los Angeles, May 14, 1958.

LITERATURE CITED

[1] API Method 751-53. *Manual on Disposal of Refinery Wastes*, Vol. IV. *Sampling and Analysis of Waste Water*, 2nd edn. (1957).

[2] *Standard Methods for Examination of Water Sewage and Industrial Wastes*, joint publication of American Public Health Assoc. and American Water Works Assoc., 10th edn., p. 260 (1955).

[3] API Method 715-53. *Manual on Disposal of Refinery Wastes*, Vol. IV. *Sampling and Analysis of Waste Water*, 2nd edn. (1957).

[4] API Method 711-53, *ibid.*

[5] API Method 724-53, *ibid.*

Hydrogen Improves Cat Cracker Feed

Hydrogen reduces the sulfur and nitrogen content of catalytic cracking feed, but it also gives some desirable conversion of hydrocarbons. Here is the story of how hydrogenation improves cracking.

M. D. Abbott, R. C. Archibald and R. W. Dorn
Shell Development Company, Emeryville, Calif.

HYDROTREATING OF catalytic cracking feedstocks not only reduces the sulfur and nitrogen contents of the oil, but, under suitable conditions, converts a large proportion of the condensed polyaromatic compounds to monoaromatics. Inasmuch as the polyaromatic nuclei crack only with great difficulty and then give rise to excessive coke, while monoaromatics lead to aromatic gasoline components, hydrogenation of catalytic cracker feed benefits both the yield structure and product distribution resulting from catalytic cracking. An added benefit of hydrogenation is the removal of metallic contaminants of the oil which would tend to deactivate the cracking catalyst; in commercial operation accumulation of these metals has had no deleterious effect on the hydrogenation catalyst.

Catalytic cracking stocks can be broadly described as mixtures of par-

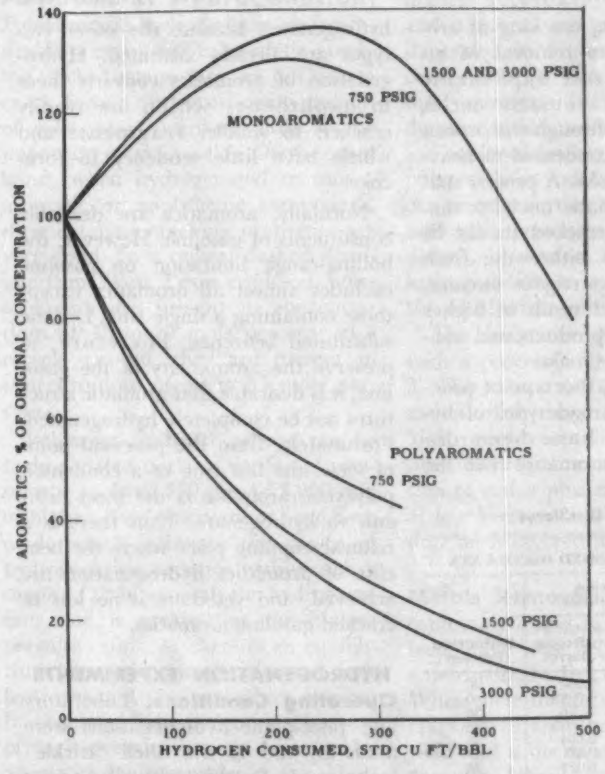


FIGURE 1—At low rates, polyaromatics are hydrogenated to monoaromatics faster than monoaromatics are saturated.

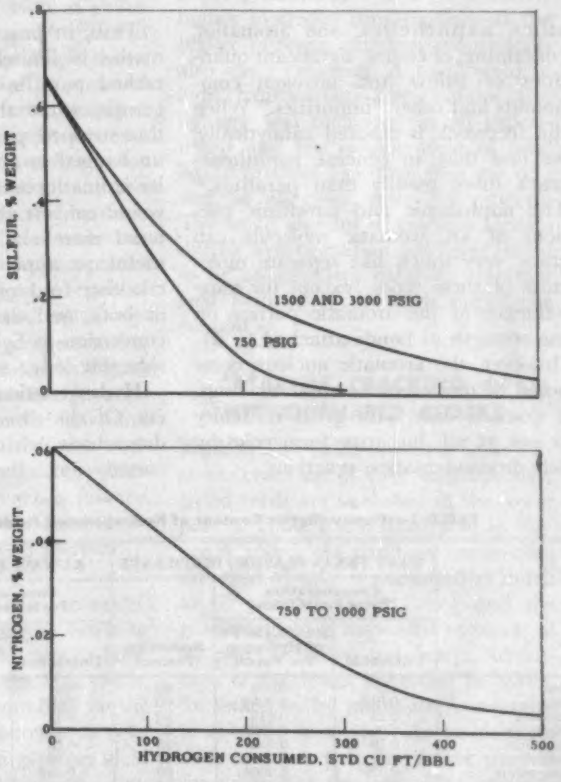


FIGURE 2—During the hydrogenation of aromatics, the process also removes sulfur and nitrogen.

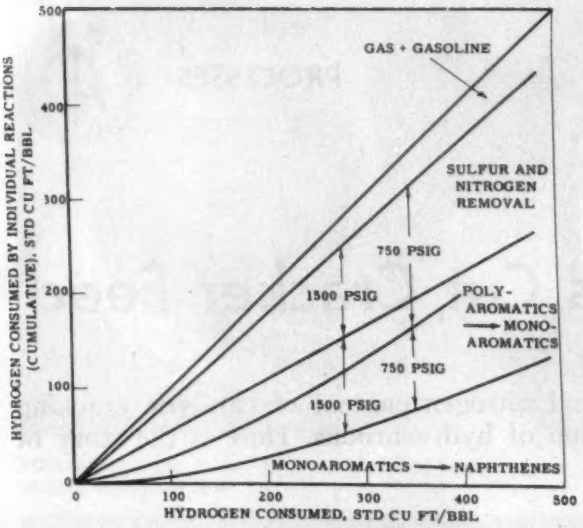


FIGURE 3—For a constant hydrogen consumption, reduction of sulfur plus nitrogen is favored at low pressure and polyaromatics reduction is favored at high pressure.

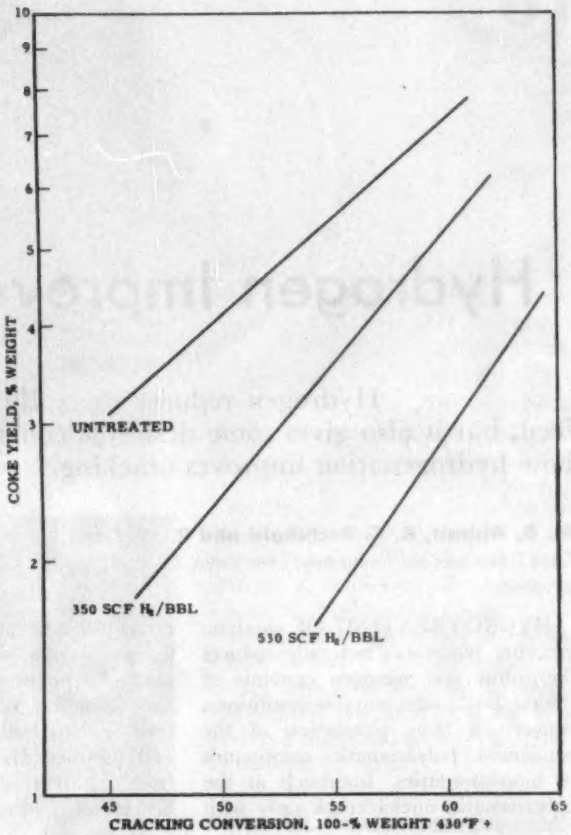


FIGURE 4—At constant conversion, the yield of coke is decreased as much as 65 percent by hydrogenating the feed.

affins, naphthenes, and aromatics, containing, of course, significant quantities of sulfur and nitrogen compounds and other "impurities." When the feedstock is cracked catalytically, we find that, in general, naphthenes crack more readily than paraffins.[10] The naphthenic and paraffinic portions of an aromatic molecule can crack very much like separate molecules of these types (except for some influence of the aromatic portion on the strength of bonds attached to it). However, the aromatic nucleus, composed of one or more aromatic rings, is cracked only with great difficulty or not at all, but may form coke by dehydrocondensation reactions.

Thus, in practice, cracking of aromatics is limited to removal of attached paraffinic and naphthenic groups, while the aromatic nuclei, thus stripped, pass through the process unchanged or are condensed to heavier aromatics and coke. A process that would convert aromatic nuclei to material more easily cracked should be useful to apply to either the fresh cracking feed or to recycle streams, or both, and should result in higher conversion to light products and considerably lower coke make.

Hydrogenation is this type of process. Of the three broad types of hydrocarbons which have been discussed, only the aromatics can be hydrogenated because the other two types are already saturated. Hydrogenation of aromatics converts them to naphthenes which are readily cracked to smaller fragments and which have little tendency to form coke.

Normally, aromatics are desirable constituents of gasoline. However, the boiling-range limitation on gasoline excludes almost all aromatics except those containing a single ring, i.e., the substituted benzenes. Therefore, to preserve the aromaticity of the gasoline, it is desirable that aromatic structures not be completely hydrogenated. Fortunately, from the practical point of view, the last ring of a condensed polycyclic aromatic is the most difficult to hydrogenate. Thus there is a natural stopping place where the benefits of aromatics hydrogenation are achieved, and yet there is no loss in cracked gasoline aromatics.

TABLE 1—Heavy-Metals Content of Hydrogenated Flashed Distillates

	WEST TEXAS FLASHED DISTILLATE			KUWAIT FLASHED DISTILLATE		
	Concentration (Parts Per Million)			Concentration (Parts Per Million)		
	Untreated	210 Std. Cu. Ft. of Hydrogen Per Barrel	Reduction (Percent)	Untreated	320 Std. Cu. Ft. of Hydrogen Per Barrel	Reduction (Percent)
Iron	1.3	0.028	95+	0.91	0.084	90
Copper	0.013	0.0049	60	0.049	0.0088	80
Nickel	0.13	0.012	90	0.17	0.026	85
Chromium	0.0046	0.0028	50	0.014	0.0035	75
Vanadium	0.19	0.013	95	0.88	0.034	95
Sodium	0.26	0.015	95	0.86	0.46	45
Magnesium	0.029	0.0064	80	0.096	0.016	85
Calcium	0.055	0.012	70	....	....	..

HYDROGENATION EXPERIMENTS

Operating Conditions. Laboratory and pilot-plant hydrogenations were made by use of the Shell "trickle" technique.[15] By this technique, gas rates are low so that a large part of

the feed remains in the liquid state as it passes downward over the catalyst. In this way, advantage is taken of the washing action of the flowing oil to carry away materials deleterious to long catalyst life. The range of other operating conditions studied includes: pressure, 500 psig to 3,000 psig; temperature, 600 F. to 800 F.; and liquid hourly space velocity, in volumes of oil per hour per volume of catalyst, 0.25 to 5.

Catalysts. Many different catalysts were employed. Included were: (1) unsupported nickel-tungsten sulfide; and (2) alumina-supported catalysts containing various combinations and concentrations of cobalt, nickel, molybdenum, and tungsten. Two supported catalysts—one containing nickel, tungsten, and molybdenum,[11] and the other containing nickel and molybdenum[12]—were among the most active catalysts tested. In addition, the materials cost for the supported nickel-molybdenum catalyst was less than for the more common alumina-supported cobalt-molybdenum catalysts containing equal weights of active metals.

Polyaromatics Hydrogenation. Polyaromatic hydrocarbons are undesirable components in catalytic cracking stocks because they are difficult to crack, form a disproportionate amount of coke, and contribute little to the important product yields. On the other hand, when hydrogenated to monoaromatic or naphthenic compounds, their catalytic cracking properties are very good. In a typical flashed distillate from West Texas crude oil, polyaromatics are present in concentrations of 15 to 20 mole percent; in a recycle gas oil, they are present in concentrations of 30 to 35 mole percent.

Polyaromatic hydrocarbons can be hydrogenated under a variety of pressures, e.g., from 750 psig to 3,000 psig or higher. Two observations have been made which influence the choice of hydrogenation pressure within such a range: (1) in general, the hydrogenation rate is greatest at the highest pressure; and (2) there is an equilibrium between polyaromatics and their hydrogenated products which is more favorable at high pressures. Thus use of high pressure greatly favors polyaromatics hydrogenation.

Figure 1 displays the mono- and polyaromatics contents of a low-sulfur West Texas flashed distillate after hydrogenation to various degrees. At the lower hydrogen consumption, polyaromatics are hydrogenated to monoaromatics more rapidly than the latter are saturated. Thus the monoaromatics concentration increases to a point where equilibrium between poly- and monoaromatics is established. Following this maximum in the monoaromatics curve, the equilibrium is maintained and both poly- and monoaromatics disappear at a rate corresponding to the rate of saturation of monoaromatics. Of course, the equilibrium concentrations and the rates vary with hydrogen pressure, and it will be observed that the reduction of polyaromatics is greater at higher pressures for a given hydrogen consumption.

Sulfur and Nitrogen Removal. During the hydrogenation of aromatics, heteroatoms, such as sulfur and nitrogen, are removed.[1-9] This is illustrated in Figure 2, which shows that sulfur is more easily removed than nitrogen. In general, excellent desulfurization and nitrogen removal are achieved under the conditions for polyaromatics hydrogenation, and this can be even further improved by using higher temperatures. Under such conditions, however, the polyaromatics hydrogenation is lower as a result of the equilibrium mentioned previously.

The destination of hydrogen during such a process is illustrated in Figure 3. This shows the difference in utilization of hydrogen under low and high pressure conditions. For a constant hydrogen consumption, reduction of sulfur plus nitrogen is favored at low pressure and polyaromatics reduction is favored at high pressure.

Metals Removal. Heavy metals, commonly found in catalytic cracking feed, have long been known to have a detrimental effect on cracking yields. When these metals accumulate on the cracking catalyst, an increase in coke yield and a decrease in gasoline yield normally follow. Passage over a hydrogenation catalyst is an effective means for removing these metals from the cracking-unit feed. Table 1 shows mild hydrogenation of both West Texas and Kuwait flashed distillates results in rejection of 80 to 95 percent of the metals.

Hydrogenation Yields. For certain specific feedstocks, the yields and properties of products are illustrated in Table 2. This table includes data for light and heavy flashed distillates and a heavy catalytically cracked gas oil. This last material is representative of either a catalytic recycle stock of one which could be fed to the second stage of a two-stage catalytic cracking unit. Data are given for operation at both 750 psig and 1,500 psig.

Excellent sulfur removal is indicated at both pressure levels. Indicated polyaromatic reduction is greater at the higher than at the lower pressure, and as a result of the higher hydrogen consumptions at the higher pressure, nitrogen reduction is also more extensive. A small yield of light hydrocarbon gas (butane and lighter) was measured in all experiments and the volume yield of total liquid product (gasoline plus gas oil) was, in all cases, over 100 percent. The small amount of gasoline formed during hydrogenation has been found to be an excellent catalytic reformer feed because of the high naphthene content.

CATALYTIC CRACKING OF HYDROGENATED STOCKS

Yields. The yields obtained from catalytic cracking of raw and hydrogenated feeds are as shown in the lower part of Table 2 and illustrated in Figure 4 and 5. At constant conversion, the yield of coke is decreased as much as 65 percent (basis coke) and the gasoline yield is improved as much as 20 percent (basis gasoline). Advantage of the lower coke can be taken, for example, by increasing conversion to obtain a constant coke yield; these data are shown in the lower part of the table. For this operation, gasoline yield is improved as much as 40 per-

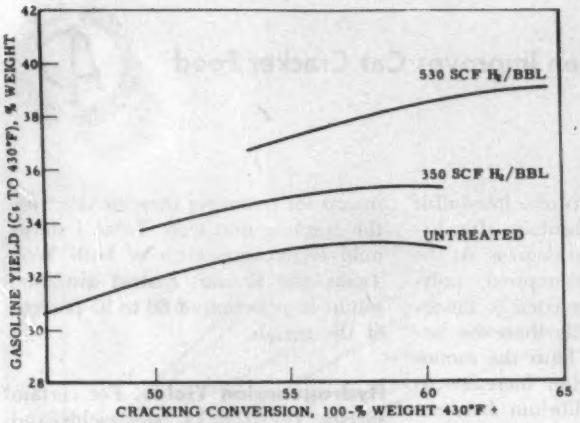


FIGURE 5—Gasoline yields are improved as much as 20 percent.

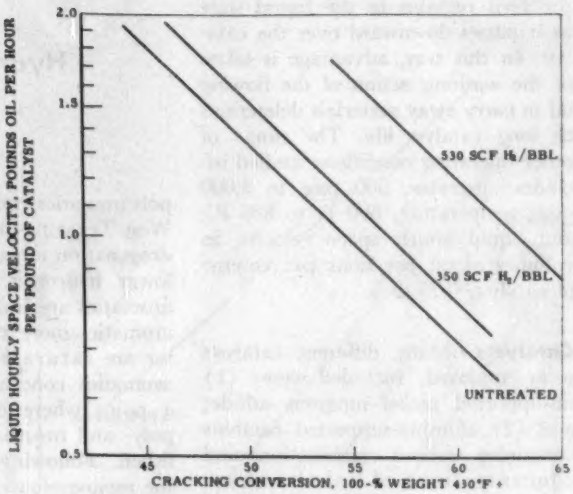


FIGURE 6—A further advantage of hydrogenation is that it permits the use of higher space velocity.

cent (basis gasoline). Table 3 shows that the benefits of increased gasoline and decreased coke are complemented by a lower dry-gas yield (ethane and lighter) and an increase in the yield of propylene and butylenes.

A further advantage of hydrogenation is that it permits the use of higher space velocity. Figure 6 indicates that with 530 standard cubic feet of hydrogen per barrel in the flashed distillate, the space velocity in a laboratory fluidized fixed-bed catalytic cracking unit can be increased by approximately 80 percent relative to that required for the untreated feed.

All of the catalytic cracking data reported herein were obtained with the use of the same catalyst for both the untreated feed and the hydrogenated gas oils. The catalytic cracking yields do not, therefore, reflect the additional yield advantage which results when the hydrogenated gas oil is cracked over a catalyst having a lower contaminant-metal content than the catalyst used for the untreated feed. This additional yield advantage should be obtained in commercial operation because of the metals reduction obtained through hydrogenation.

Product Quality. In addition to the yield advantages, the quality of the gasoline and gas oil from a hydrogenated feedstock is superior to that from an untreated feed. This is illustrated in Table 4. Catalytic gasoline from the hydrogenated feed tests higher in octane number, both Motor and Research, and lower in sulfur content. For the light gas oil, sulfur is decreased appreciably, diesel index

TABLE 2—Experimental Hydrogenation of Catalytic Cracking Feedstocks

	West Texas Flashed Distillate			Extra-Heavy West Texas Flashed Distillate			Kuwait Flashed Distillate			Catalytically Cracked Heavy Gas Oil	
Hydrogenation:											
Pressure, psig	....	750	1,500	....	750	1,500	....	750	1,500	....	750
Hydrogen consumed, std. cu. ft. per bbl.	None	350	530	None	240	570	None	375	455	None	500
Reduction, per cent:											
Sulfur	....	93	97	....	76	96	....	85	89	....	94
Nitrogen	....	61	85	....	24	82	....	37	63	....	29
Polyaromatics	....	48	73	....	23	69	....	43	65	....	34
Yields, per cent by weight of hydrogenation feed:											
Hydrocarbon gas (butane and lighter)	....	0.3	0.6	....	0.5	0.7	....	0.3	0.3	....	0.2
Heterogas (hydrogen sulfide, ammonia, steam)	....	1.7	1.8	....	1.5	2.2	....	2.6	2.7	....	1.7
Gasoline (C_5 to 450 F.)	....	2.9	4.0	....	2.2	1.9	1.3	2.7	3.3		
Gas Oil	100.0	95.6	94.5	100.0	96.2	96.2	98.7	95.1	94.5	100.0	99.0
Yield of total liquid product (gasoline plus gas oil), percent by volume	100.0	100.6	101.5	100.0	100.9	101.1	100.0	101.0	101.7	100.0	101.7
Properties of Catalytic Cracking Feed:*											
Gravity, deg. API	25.5	28.4	29.9	22.1	25.7	26.5	23.4	28.4	29.5	21.5	25.7
Sulfur, percent by weight	1.68	0.12	0.05	1.82	0.44	0.07	2.91	0.44	0.32	1.52	0.09
Nitrogen, percent by weight	0.13	0.05	0.02	0.17	0.13	0.03	0.08	0.05	0.03	0.07	0.05
Monoaromatics, millimoles per 100 g.	67	81	78	57	73	78	63	91	97	39	70
Polyaromatics, millimoles per 100 g.	59	31	16	65	50	20	62	36	22	126	83
Molecular weight	349	....	....	464	....	....	374	....	....	305	290
Catalytic Cracking Yields, Percent by Weight of Cracking Feed:											
At constant conversion:											
Conversion (100 minus percent by weight of 430+ F material)	56	56	56	60	60	60	55	55	55	50	50
Coke Yield	5.8	3.9	2.0	6.8	5.0	2.2	5.6	3.7	2.5	12.6	7.1
Gasoline yield (C_5 to 430 F.)	33.1	35.2	37.5	37.8	39.0	41.7	32.6	35.7	37.1	23.1	28.1
At constant coke:											
Conversion (100 minus percent by weight of 430+ F material)	49.5	56.3	63.4	53.0	60.0	69.0	49.7	56.2	60.0	42.5	56.5
Coke yield	4.0	4.0	4.0	5.0	5.0	5.0	4.0	4.0	4.0	10.0	10.0
Gasoline Yield (C_5 to 430 F.)	31.8	35.2	39.0	35.6	39.0	43.1	31.8	36.0	38.3	21.0	29.3

* Hydrogasoline (C_5 to 450 F.) remained in catalytic cracking feed in the Kuwait and the cracked-gas-oil studies. Hydrogasoline was distilled out of catalytic cracking feed in the West Texas flashed-distillate studies.

is higher, and color stability is improved. These advantages make possible both a better furnace oil and a better diesel fuel from a hydrotreated feed to catalytic cracking. The increase in gravity and decrease in sulfur, nitrogen, and viscosity of the heavy gas oil indicate an improved thermal cracking feed.

COMMERCIAL OPERATION

A commercial unit for hydrogenation of catalytic cracking feedstock has been operated by Shell Oil Company of Canada, Limited, for approximately one and a half years. Typical performance data, obtained while processing Kuwait flashed distillate, are shown in Table 5. Although operations are adjusted to give a mild treatment, a substantial improvement in the quality of catalytic cracking feed is indicated by the 4-unit increase in API gravity, 80 percent reduction in sulfur, and 65 percent reduction in Conradson carbon. The 42 percent reduction in polyaromatics shows up as an equivalent increase in monoaromatics content. An improvement in color and a 25 percent reduction in basic nitrogen content are also indicated.

The hydrogenated Kuwait flashed distillate usually is catalytically cracked in admixture with untreated feeds from other crude-oil sources. A series of tests has, however, revealed the yield changes which would result if the Kuwait stocks were cracked alone. Comparative cracking yields are shown at the bottom of Table 5. The increase in gasoline yield resulting from hydrogenation is approximately 7 percent (basis gasoline), while the decrease in the combined yield of coke and ethane and lighter is approximately 25 percent (basis coke plus ethane and lighter).

Alternatively, the improved feed quality, indicated in Table 5, can be exploited in a catalytic cracking unit which is limited only by coke-burning capacity by either of the following: 1, increasing conversion approximately 10 percent (basis feed) at constant feed rate or, 2, increasing feed rate approximately 35 percent at constant conversion.

Other benefits resulting from the feed hydrogenation are improved octane number of the catalytic gasoline and lower sulfur content of the gasoline, No. 2 fuel oil, and cutter stock. These results are in agreement with the laboratory data shown in Table 4.

Because the commercial cracking tests which have been reported herein for the untreated and the hydrogenated feeds were made within a few days of each other, the heavy-metal-contaminants content of the cracking catalysts were identical for the two tests. The cracking yields do not, therefore, reflect the additional advantage which would result if catalysts with equilibrium heavy-metals content were used in each test.

Although laboratory and plant data have indicated quite conclusively the detrimental effect of heavy metals on cracking catalysts, no comparable ill effect has been observed as the result of heavy-metals deposition on the hydrogenation catalyst. In theory, some of these deposited metals might be expected to behave like hydrogenation catalysts. In practice, no significant effect has been observed during a year and a half of commercial operation. In this connection, it is interesting to note an approximation which relates the maximum metals deposition on hydrogenation catalyst as a function of operating conditions. If a catalyst removes one part per million of heavy metals from an oil feed for one year, while operating at a liquid hourly space velocity of one, the accumulation on the catalyst will approximate one per cent.

ECONOMICS

The improvement of both catalytic cracking yield structure and product quality, which has been reported herein, can often make catalytic cracking feed hydrogenation a profitable operation. Because hydrogenation relieves the coke-burning bottleneck which limits many existing catalytic cracking units, an added economic benefit can frequently result when feed hydrogenation is installed in an existing refinery.

This added benefit can be obtained by operating the existing catalytic cracking unit either at higher conversion levels or at higher feed rates. When feed hydrogenation is provided as part of a new refinery, the corresponding added benefit is obtained largely through the reduced capital cost of the coke-burning equipment required for the catalytic cracking unit.

Straight-Run Feeds. Introduction of a new high-sulfur crude oil into a refinery may, at times, create a need for new desulfurization facilities for one or more of the catalytically cracked products. In this situation, the desired sulfur reduction may be obtained either by desulfurizing the products or by hydrogenating the feed to the catalytic cracking unit.

The economics in this case depend, in part, on the size of the required feed-hydrogenation unit relative to

TABLE 3—Catalytic Cracking Yields from Hydrogenated West Texas Flashed Distillate

	Untreated	350 Std. Cu. Ft. of Hydrogen Per Barrel	530 Std. Cu. Ft. of Hydrogen Per Barrel
Yield, percent by weight catalytic cracking feed:			
Ethane and lighter	4.9	3.7	2.6
Propylene	4.1	4.5	4.6
Propane	1.7	1.2	1.0
Butylene	3.5	4.2	4.9
Butanes	2.3	2.8	2.9
Gasoline (C_5 to 430 F)	33.0	35.0	37.2
Light gas oil (430 F. to 650 F.)	25.0	26.0	27.0
Heavy gas oil (650+ F.)	20.0	19.0	18.0
Coke	5.5	3.6	1.8
	100.0	100.0	100.0

TABLE 4—Properties of Products from Catalytic Cracking of Untreated and Hydrogenated West Texas Flashed Distillate
(Constant Conversion)

	Untreated Feed*	Hydrogenated Feed, 460 Std. Cu. Ft. of Hydrogen Per Barrel
Gasoline (70 F. to 450 F.):		
Research octane number (ASTM D 908)		
Without TEL addition	94.0	95.3
With addition of 3 ml TEL per gal	98.0	99.6
Motor octane number (ASTM D 357), without TEL addition	84.1	86.0
Sulfur, percent by weight	0.18	0.01
Light Gas Oil (450 F. to 675 F.)		
Gravity, deg. API	21.4	25.6
Sulfur, percent by weight	1.5	0.12
Aniline point, deg. F.	104	117
Diesel index	22	30
Color, ASTM:		
Without aging	1½	1¼
After aging at 212 F:		
For 24 hours	3½	1¾
For 48 hours	3¾	2½
Heavy Gas Oil (675+ F.)		
Gravity, deg. API	15.1	22.2
Sulfur, percent by weight	1.4	0.34
Nitrogen, percent by weight	0.08	0.03
Viscosity (Saybolt Universal) at 210 F., sec.	40	38

*Contains 0.6 percent of naphtha which may lower octane numbers of catalytic gasoline by approximately 0.3 units. Hydrogenated feed contains no naphtha.

the size of the product hydrodesulfurizer replaced. In some applications studies, the capital and operating costs of the feed-hydrogenation unit are only slightly greater than the comparable costs for the product treater. In this situation, the economics for catalytic cracking feed hydrogenation are quite favorable.

Second-Stage Catalytic Cracking Feeds. Economic studies have shown that two-stage catalytic cracking is often more profitable than single-stage. The first commercial unit employing this new technique was installed by Shell Oil Company at its new refinery at Anacortes, Wash.[14] Other economic studies have shown that hydrogenation of the cracked gas-oil feed to the second stage of catalytic cracking may be more profitable than hydrogenation of the straight-run feed to the first stage. This normally occurs when the desulfurization credits, which have been described herein, are not obtainable.

Other factors also contribute to the favorable economics for hydrogenation of a heavy catalytically cracked gas-oil feed to the second stage of two-stage catalytic cracking. First, experimental data indicate that the extent of improvement in catalytic cracking yields is related to the total quantity of polyaromatics hydrogenated. Second, catalytically cracked gas oils contain high concentrations of polyaromatics and, therefore, the potential improvement is great. Third, theoretical considerations and experimental data shown that catalytically cracked gas oils are more easily hydrogenated than are straight-run stocks. Therefore, a big improvement can be made in quality while employing mild hydrogenation conditions. Inasmuch as use of mild hydrogenation conditions leads to low capital and low operating costs, favorable economics are obtained.

TABLE 5—Performance of Commercial Catalytic Cracking Feed-Hydrogenation Unit

	Feed	Stripper Liquid Tops	Stripper Bottoms
Hydrogenation:			
Yield, percent by volume	100	0.7	99.9
Gravity, deg. API	23.2	45.4	27.3
Sulfur, percent by weight	2.78	0.38	0.58
Conradson carbon, percent by weight	0.45	....	0.16
Monoaromatics, millimoles per 100 g.	62	....	91
Polyaromatics, millimoles per 100 g.	62	....	36
Nitrogen (basic), ppm	470	....	360
Color, NPA	7	....	3
Research octane number (ASTM D 908):			
Without TEL addition	....	47.3	....
With addition of 3 ml TEL per gal.	....	69.1	....
ASTM distillation, deg. F.:			
Initial boiling point	582	120	460
50-percent point	680	426	680
Catalytic Cracking:			
Conversion (100 minus percent by weight of 450+ F material)	57.7	....	58.4
Yields, percent by weight of catalytic cracking feed:			
Gasoline (C_5 to 450 F)	35.1	....	37.6
Coke	6.1	....	4.4
Ethane and lighter	3.8	....	3.0

The economics for hydrogenating heavy catalytically cracked gas-oil feed to the second stage have been evaluated for new refinery construction. The evaluation was made by calculating the capital and operating costs for two hypothetical refineries with a digital-computer.

Both refineries employed: *(a)* crude-oil distillation; *(b)* flash cracking; [13] *(c)* two-stage catalytic cracking; [14] *(d)* catalytic reforming; *(e)* catalytic polymerization of both propylene and butylene; and *(f)* hydrodesulfurization[15] of No. 2 fuel oil. One refinery employed hydrogenation of the feed to the second stage of catalytic cracking; the second did not. Crude-oil input to the two refineries was adjusted to give an equal total production of both gasoline and No. 2 fuel oil. Results of this study indicated that the added capital cost of the refinery employing catalytic cracking feed hydrogenation was returned in less than two years.

In a supplementary calculation, the value of the products from the second stage of catalytic cracking was estimated by the use of Gulf Coast cargo low prices. This calculation indicated that the products from the hydrogenated feed were valued at approximately 50 cents per barrel of feed more than the products from the untreated feed. This differential remained approximately constant for all conversion levels studied (45 to 60 percent).

Costs. Capital and operating costs of hydrogenating catalytic cracking feed will vary with the capacity, operating pressure, required space velocity, and construction standards. The required pressure and space velocity will, in turn, vary with the properties of the feed. In general, however, capital costs are in the range of $100 to $200 per daily barrel of capacity; the direct operating cost, which includes utilities, labor, maintenance, and catalyst, is normally less than 10 cents per barrel of feed.

Original presentation was before the American Petroleum Institute, Division of Refining, Los Angeles, May 14, 1958.

ACKNOWLEDGMENT

The authors wish to express their appreciation to personnel of the Shell Oil Company of Canada, Limited, for supplying data from their commercial operation, and to personnel of the Houston Research Laboratory of Shell Oil Company for their contribution of a portion of the catalytic cracking data. The results of experimental work and assistance offered by associates at Emeryville are also gratefully acknowledged.

LITERATURE CITED

[1] C. L. Brown, A. Voorhies, Jr., and W. M. Smith. "Cycle Stocks from Catalytic Cracking-Hydrogenation and Desulfurization," *Ind. Eng. Chem.* 38 [2] 136-40 (1946).
[2] A. Voorhies, Jr., and W. M. Smith. "Desulfurization-Hydrogenation of High-Sulfur Catalytically Cracked Cycle Oil, *Ind. Eng. Chem.* 41 [12] 2708-10 (1949).
[3] H. W. Grote, C. H. Watkins, H. F. Poll, and G. W. Hendricks. "Unifining—A New Petroleum Process," *Petroleum Refiner*, 33 [4] 165 (1955).
[4] J. G. Eckhouse, C. F. Gerald, and A. J. de Rosset. "Unifining Upgrades Distillate Fuels," *Oil Gas J.* 53 [17] 81-3 (1954).
[5] W. H. Winslow, and J. Weikart. "Processing of Heavy High-Sulfur Crude Oil in a Low-Sulfur Refinery," *Proc. API* 35 [111] 352-8 (1955), *Petroleum Refiner*, 34 [9] 220 (1955).
[6] G. H. Hemmen, A. E. Kelley, M. J. Sterba, and D. Reed, Jr., "Unifining—A Proven Refining Technique," *Proc. API* 35 [111] 334-44 (1955).
[7] E. H. Lewis. "Hydrofining Catalytic Cracking Feedstocks," *Oil Gas J.* 54 [11] 95-6 (1955).
[8] J. McAfee and W. A. Horne, "Hydrogen Treating," *Petrol. Processing* 11, 47-52, April (1956).
[9] C. R. Eberline, R. T. Wilson, and L. G. Larson. "Hydrotreating Cracking Stocks," *Ind. Eng. Chem.* 49 [4] 661-3 (1957).
[10] B. S. Greensfelder, H. H. Voge, and G. M. Good. "Catalytic Cracking of Pure Hydrocarbons," *Ind. Eng. Chem.* 37 [12] 1168-76 (1945).
[11] K. Nozaki. "Hydrogenation of Hydrocarbon Oils, Tungsten, Molybdenum, and Nickel Containing Catalysts Therefore, and Their Preparation," U. S. Patent 2744052.
[12] K. Nozaaki, "Hydrogenation of Aromatics and Sulfur Bearing Hydrocarbon Oils and Catalysts Therefore," U. S. Patent 2758957.
[13] W. V. Medlin, J. C. Ornea, and A. J. Johnson. "Catalytic Cracking Feed Preparation," presented to a session on processes during the 23rd Midyear Meeting of the American Petroleum Institute's Division of Refining, in the Statler Hotel, Los Angeles, Calif., May 13, 1958, *Petroleum Refiner*, 37 [5] 167 (1958).
[14] J. D. Heldman, F. Kunreuther, J. A. Marshall, and C. A. Rehbein. "Commercial Two-Stage Fluid Cracking," *Proc. API* 36 [111] 258-64 (1956), *Petroleum Refiner*, 35 [5] 166 (1956).
[15] H. Hoog, H. G. Klinkert, and A. Schaafsma. "Shell Hydrodesulfurization Process," *Proc. API* 33 [111] 71-8 (1953), *Petroleum Refiner*, 32 [5] 137 (1953).

About the Speaker

M. D. Abbott is a member of Shell's Oil Process Engineering department at Emeryville, Calif. He has been active for many years in development, process design, and economic evaluation of oil refining processes. He attended the Massachusetts Institute of Technology from 1933 to 1938. Before joining Shell in 1953, he worked for Humble Oil and Refining Co. and C F Braun and Co. During World War II he worked on the Manhattan Project in Chicago.

Process Feed For More Cat Gasoline

More catalytic cracked gasoline can be made by recovering a greater percentage of crude oil for cracking feedstock. Examine this comparison of some feed preparation methods.

W. V. Medlin, J. C. Ornea and A. J. Johnson
Shell Development Company
Emeryville, Calif.

CATALYTIC CRACKING is an important refining tool for the production of ever-increasing quantities of high-quality gasoline. The trend in feed preparation is to produce larger quantities of distillates suitable for catalytic cracking feed.

There has been an increase in the production of gasoline, as shown in Figure 1, where the production ratio of gasoline to fuel oil is plotted annually for the period since 1932. The most interesting aspect of the plot is the relatively rapid increase in this ratio since the war; it reflects the relatively rapid increase in gasoline demand during this period. For the most part, this demand has been satisfied by the construction of catalytic cracking capacity. This capacity has been employed, first, to process more of the crude oil being charged to refineries and, second, to recover greater and greater percentages of this crude oil for feedstock.

California crude oils are less responsive to ordinary vacuum flashing and catalytic cracking than Mid-Continent and Texas crude oils. However, the use of special processes for feed preparation are especially effective with them. The processes which will be discussed are those which produce high yields of catalytic cracking feedstock, i.e., "deep feed-preparation" processes.

Vacuum flashing is a widely used method of preparing feedstocks. The yield of overhead product from vacuum flashing depends upon the pressure and temperature employed at the effective flash point measured at the cyclone inlet. Figure 2 is an illustration of the effect of flash pressure and temperature upon the yield in a single flash separation. It is seen that at the maximum temperature of 800 F. the amount flashed increases from 50 percent to 80 percent as the pressure is reduced from 600 mm to 25 mm. Thus the performance of the vacuum flasher depends greatly upon the pressure for which it is designed.

Judging from the information in Figure 2, one obvious way of increasing the proportion of crude oil charged to catalytic cracking is to build vacuum flashers of lower pressure, or to build secondary high-vacuum flashers operating upon regular vacuum-flasher pitch. In the case of Los Angeles Basin crude oil, the

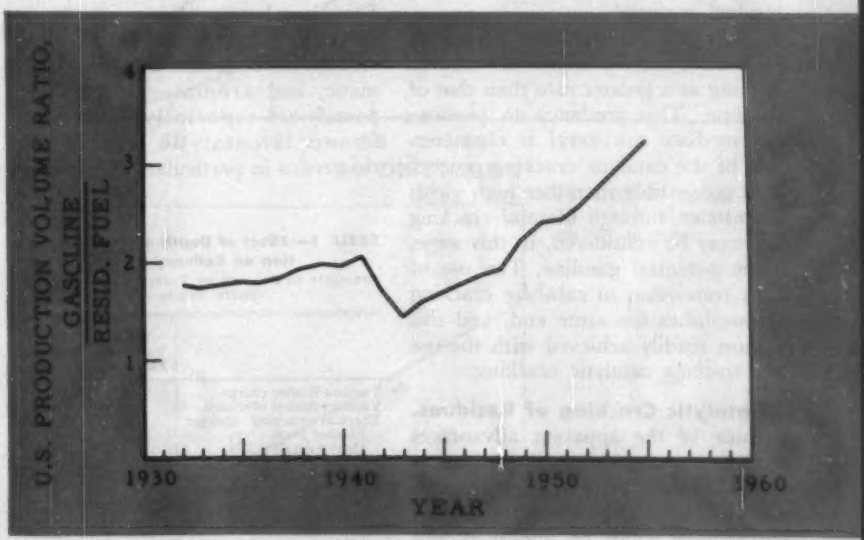


FIGURE 1—There is an increase in the production of gasoline relative to other products obtained from crude oil.

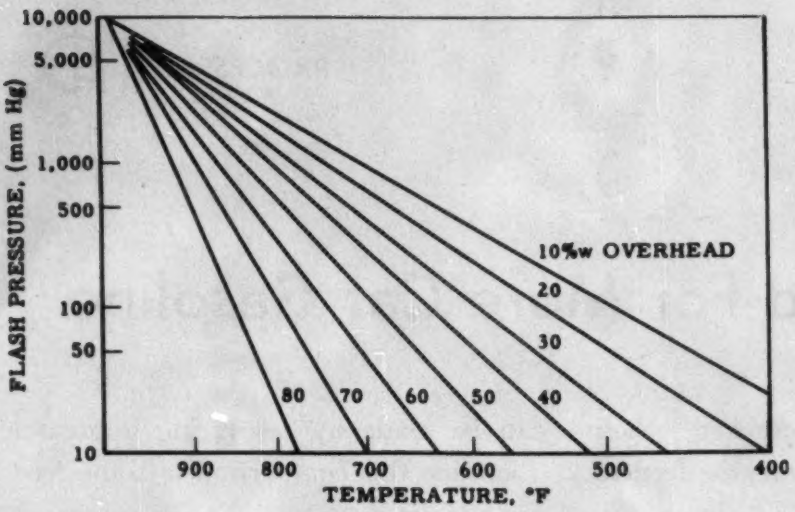


FIGURE 2—The performance of the vacuum flasher depends greatly upon the pressure for which it is designed.

effect of doing this is illustrated in Table 1. As the vacuum-flasher pressure is reduced, the percentage of crude oil being charged to catalytic cracking rises, and pitch yield is correspondingly reduced. Using single-stage, once-through catalytic cracking upon the vacuum-flashed material, the most noteworthy change in yield structure shown is a substantial reduction in No. 6 fuel oil and a corresponding increase in yield of lighter distillate and gasoline. The decrease in the ratio of residual fuel oil to gasoline is 24 percent with a corresponding increase in No. 2 fuel oil, and this is accomplished in the present example with a crude oil which by nature produces a relatively high yield of this residual material.

The yield of distillate fuel rises with increasing depth of vacuum flashing at a greater rate than that of gasoline. This tendency to produce intermediate material is characteristic of the catalytic cracking process. It is convertible in rather high yields of gasoline through thermal cracking and may be considered, in this sense, to be potential gasoline. The use of high conversion in catalytic cracking accomplishes the same end, and this is most readily achieved with the use of two-stage catalytic cracking.

Catalytic Cracking of Residues. Because of the apparent advantages in charging very deeply flashed material to catalytic cracking units, a question may be raised as to whether feed preparation could be abolished and the entire long residue catalytically cracked. Such an operation is indeed carried out in some instances, notably in the Houdresid process employed by Sun Oil Company in a moving-bed unit at Sarnia, Ontario, and in a fluid unit by Frontier Refining Company at Cheyenne, Wyo.[2] We believe, however, that with most feedstocks and in most refineries such an operation, although technically feasible, might not be economically desirable. This would be especially true of Los Angeles Basin residue. An illustration of the type of problem which would be encountered is given in Figure 3, where analytical data are presented for fractions distilled under vacuum from straight-run residue derived from the atmospheric-pressure distillation of Los Angeles Basin crude oil. From catalytic cracking experiments on purified fractions, it has been previously learned that resins, polyaromatic, and aromatic sulfur compounds are especially severe coke formers in catalytic cracking, and that resins in particular tend to crack almost completely to coke. The curves in Figure 3 indicate that the sum of resins, polyaromatic, and aromatic sulfur compounds rises rapidly with percent distilled, reaching 80 percent at 70-percent overhead. At the same overhead yield, resins alone account for more than 40 percent of these compounds. The implication from these data would be that extremely high coke yields would be obtained from the marginal overhead material as the latter approached 100 percent. In view of the high cost of burning carbon from catalyst, it seems obvious that the last 10 or 20 percent of Los Angeles Basin straight-run residue should not be catalytically cracked.

TABLE 1—Effect of Depth of Feed Preparation on Refinery Yields

Amounts in Percent by Volume of Los Angeles Basin Crude Oil

	Mild Vacuum Flashing	Deep Vacuum Flashing
Vacuum-flasher charge	53.0	53.0
Vacuum-flasher overhead	21.5	42.5
Thermal cracking charge:		
Flasher pitch	31.5	0
Heavy catalytically cracked gas oil	4.5	9.0
Platformer charge	16.7	16.7
Yields of principal products:		
10-Lb-RVP gasoline	44.7	45.3
No. 2 fuel oil	11.3	14.5
No. 6 fuel oil	36.5	28.1
ASTM octane number (D 908 Research Method), with 3 ml TEL	96.4	97.6

An even more serious argument for feed preparation, however, lies in the tendency of metals to concentrate in the heaviest residual fractions. Figure 4 illustrates this tendency. Here the total amounts of nickel plus vanadium in overhead products are plotted for vacuum flashing as a function of percent by weight of overhead distillate, and a very strong increase with percent flashed may be noted. Metallic contamination of cracking catalyst has been shown to affect catalyst activity and product distribution, particularly in increased coke yields.

The economic effect of metals in the feed to a catalytic cracking unit is not known with certainty and varies depending upon plant operating conditions, the metals concentration in the feed, catalyst activity, etc. In our attempts to determine a figure for the cost of metals, it has turned out that this cost probably lies in the range $200 to $1,000 per pound of nickel plus vanadium charged to the unit with the feed. Taking as correct the arbitrary figure of $300 per pound, Figure 5 indicates that at the 80 percent overhead level the metals concentration in the incremental feed is such that it costs approximately $12 per barrel to charge it to the unit. Even at 62 percent overhead, this cost may be as much as $1 per barrel. And even if we accept these figures as order-of-magnitude calculations only, it is quite evident that a severe limitation exists as to the amount of feedstock that can economically be taken overhead in a flashing operation. No other feed-preparation process can be used at high yields, either, unless it is much more effective than vacuum flashing in removing the bulk of the metal contaminants.

At least for Los Angeles Basin resi-

due, therefore, a feed-preparation unit is necessary to the economic operation of a catalytic cracking unit. As mentioned before, however, it is desirable to approach the charging of residue by preparing as much catalytic cracking feed from it as is feasible, in order to improve the refinery yield structure. Although Figure 5 has indicated that, at least with Los Angeles Basin crude oil, metals contamination may prevent the use of deep vacuum flashing for this purpose, other processes are available which tend to overcome this disadvantage, and their brief descriptions may be of use.

DEEP FEED-PREPARATION PROCESSES

Flash Cracking is a term given to the combination of viscosity breaking and vacuum flashing of long residue. The yield of pitch from the flash cracking unit may be as little as 10 percent of the Los Angeles Basin crude oil. It is partially cracked, but can be mixed with aromatic cutter stock to produce a fuel meeting the viscosity specifications for No. 6 fuel oil. When cooled, it solidifies into a hard, brittle tar having a softening point between 250 F. and 300 F. The substance resembles coke and may be handled in a similar fashion; for example, it is easily ground and can be utilized as furnace fuel with proper handling equipment. Thus the flash cracking process may be said to have the flexibility to permit operation to either blended fuel for sale or an underboiler coke-like material, as desired. The yield of blended fuel as a function of pitch yield is illustrated in Figure 6, together with a point representing a normal refinery operation with vacuum flashing followed by thermal cracking of flasher pitch. It is seen that for the same yield of pitch in the feed-preparation unit, the flash cracking unit makes more No. 6 fuel oil. At lower pitch yields, the production of No. 6 fuel oil is reduced below the present level. Thus flash cracking has the effect of reducing refinery yield of No. 6 fuel oil without the necessity for further thermal cracking of flasher pitch.

Solvent extraction is an alternative deep feed-preparation process for vacuum-flasher pitch.[3] This process has been applied commercially at several locations. The cost, including the preceding vacuum flasher, has been found to be somewhat higher than that of the previously described flash cracking unit, and the yield of overhead product is approximately the same. The selectivity of the solvent is such that the quality of the overhead deasphalted oil is somewhat better for the same yield and metal separation is improved—both as compared to vacuum flashing.

Coking is a third alternative approach to deep feed preparation. The technique of delayed coking was in use for many years before catalytic cracking was known, and has been used to some extent since that time as a feed-preparation process, notably by General Petroleum Corporation in California.[4] Low pressures are desirable to obtain vaporization with minimum cracking, and thus maximum yields of distillates of good quality result. In spite of this, rather substantial amounts of low-quality gasoline are obtained, and distillates are degraded to some extent as catalytic cracking feedstocks.

Fluid coking, as introduced by Esso Standard Oil Company, overcomes this disadvantage rather well. The two largest fluid coking units have capacities of 42,000 barrels per day and are operated by Tidewater Oil Company at Avon, Calif., and in the new refinery at Delaware City, Del.[6]

The various feed-preparation proc-

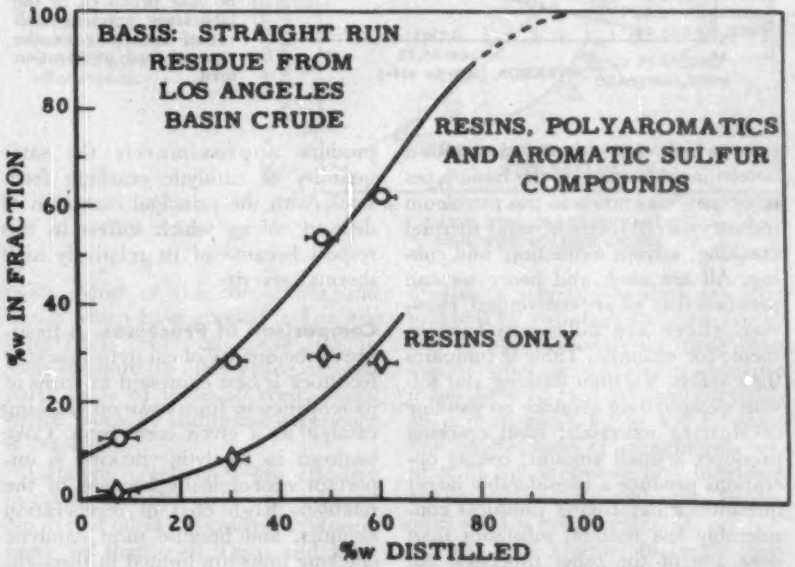


FIGURE 3—Resins tend to crack almost completely to coke.

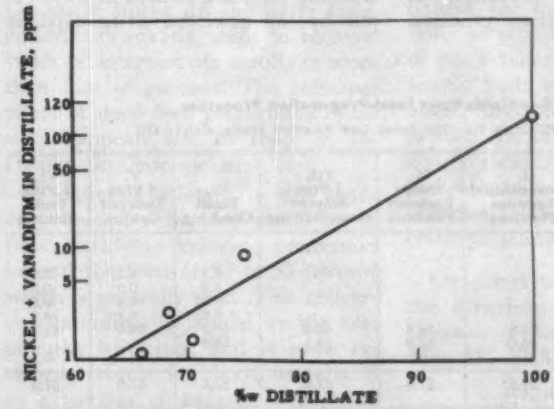


FIGURE 4—Metallic contamination affects catalyst activity and product distribution adversely.

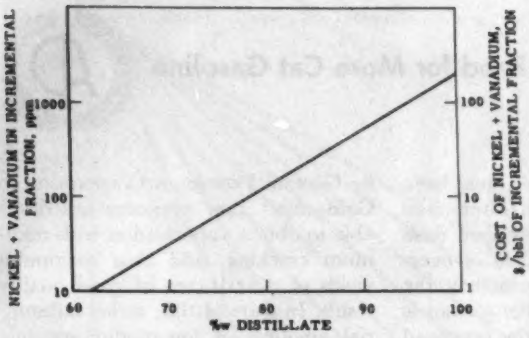


FIGURE 5—At the 80 percent overhead level, metals increase the cost of operation about $12 per barrel of charge.

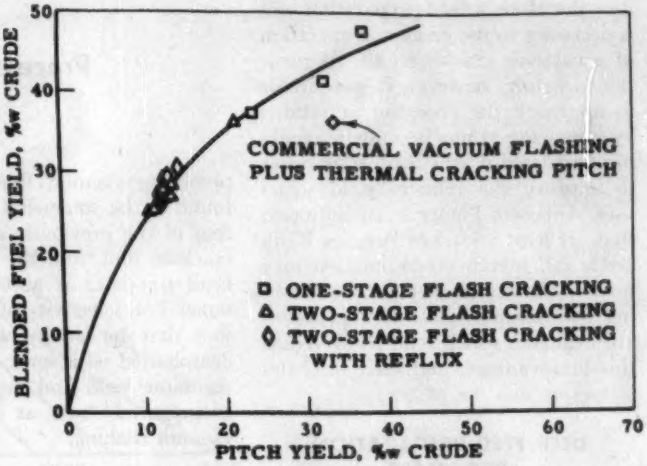


FIGURE 6—The flash cracking unit makes more No. 6 fuel oil.

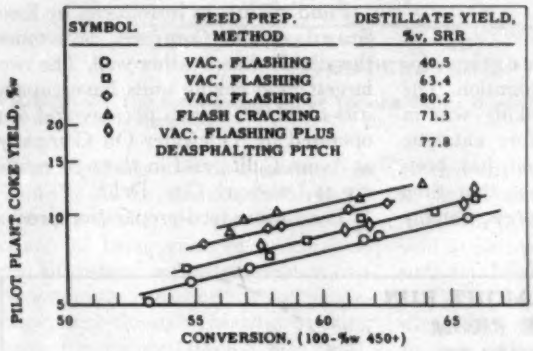


FIGURE 7—The amount of coke produced in the laboratory cracking unit varied according to the type of feed preparation used.

esses which have been described herein include most of the basic types of operations known to the petroleum industry: distillation, mild thermal cracking, solvent extraction, and coking. All are used, and hence we can presume that all are economical. However, there are differences between them; for example, Table 2 compares their yields. Vacuum flashing and solvent deasphalting produce no gasoline or lighter materials; flash cracking produces a small amount; coking operations produce a considerably larger quantity. Fluid coking produces considerably less residual substance than does any of the other processes. All the deep feed-preparation processes produce approximately the same quantity of catalytic cracking feedstock, with the principal exception of delayed coking which suffers in this respect because of its relatively high thermal severity.

Comparison of Processes. A measure of the quality of catalytic cracking feedstock is best expressed in terms of its tendency to form coke on cracking catalyst at a given conversion. Coke laydown in catalytic cracking is important economically because of the relatively high cost of regeneration facilities, and because most catalytic cracking units are limited in throughput by the coke-burning capacity available. In Figure 7 is shown the amount of coke produced in a laboratory fluid-bed catalytic cracking unit for three depths of feed preparation by vaccum flashing and, for comparison, by the alternative processes of deasphalting and flash cracking. An advantage is shown for deasphalting; at approximately the same overhead yield deasphalting appears to be somewhat better than vaccum flashing, and flash cracking somewhat worse. These figures reflect the improved selectivity of the solvent extraction process and the relative degradation in the mild thermal cracking operation. The coking processes, although not shown, produce distillates with high coke yields relative to vacuum flashing, with delayed coking giving the poorer product.

In metals rejection there is a somewhat different order of effectiveness. Figure 8 illustrates the results of our analyses of overhead products for nickel and vanadium as functions of distillate product. The improvement for deasphalting over vacuum flashing is evident and reflects again the better selectivity in the extraction process. Flash cracking, however, appears to be still better. Metal-containing compounds are preferentially decomposed in the mild cracking step; indeed, observations have shown, in a number of instances, that the volatility of metallic compounds is greatly reduced with very mild thermal treatment. In the comparisons of processes, this advantage in metals rejection more or less offsets the disadvantage which has been described for the thermal deg-

TABLE 2—Yields from Feed-Preparation Processes

Feed: Straight-Run Residue from Los Angeles Basin Crude Oil

Process:	I, Conventional Vacuum Flashing	II, Deep Vacuum Flashing	III, I Plus Solvent Deasphalting	IV, Flash Cracking	V, I Plus Delayed Coking	VI, I Plus Fluid Coking
Yield, percent by weight of crude oil:						
C_3	....	....	....	0.3	2.2	2.0
C_4	....	....	....	0.2	0.9	0.8
C_4	....	....	....	0.2	0.9	0.5
Naphtha	....	....	....	2.9	6.1	4.2
Distillate	22.6	44.6	43.5	40.2	36.6	43.8
Pitch	35.0	13.0	14.1	13.8	....	....
Coke	....	....	....	....	10.9	6.3
	57.6	57.6	57.6	57.6	57.6	57.6

radation of the product, making the two processes relatively close together economically. Two points are shown in Figure 8 for a process in which deasphalting is substituted for the vacuum-flashing stage in a flash cracking operation. The improvement over mild flashing plus deasphalting is evident and again reflects the destruction of metallic compounds as a result of cracking. Without a direct comparison at the same overhead yield, it is difficult to say if this combination is more effective than two-stage flash cracking, inasmuch as it does not involve the return of recycle which has been found effective in reducing metallic contaminants in the flash cracking process.

No comparative information is available on metals rejection in coking as compared to the processes displayed in Figure 8. The rejection of metals would be expected to be at least as good as for flash cracking for the same overhead boiling range.

For clean crude oils containing little pitch, such as Louisiana crude oils, deep vacuum flashing has been found to be adequate, and more severe devices are probably not justified. Coking is somewhat more expensive than the alternatives discussed; its profitability depends greatly upon the future outlook for the residual-fuel market. Although residual fuel just now is selling at too high a price to make coking attractive, the long-term trend which has been discussed may ultimately operate in favor of fluid coking for deep feed preparation. As between flash cracking and vacuum flashing-deasphalting, a careful comparison made for West Texas and Alberta crude oils represent a tossup economically. Capital costs slightly favor flash cracking, and there is a considerable saving in direct operating costs as well. These are offset, to some extent, by the obvious advantage that deasphalting has of producing a superior catalytic cracking feedstock and no thermally cracked products. California crude oils appear to favor flash cracking because of the much better rejection of contaminating metals which it achieves.

Flexibility of operation is an intangible point to be taken into consideration in comparisons of this sort. It is believed flash cracking is perhaps the most flexible on two principal counts. First, it can accept considerable variation in crude-oil properties, particularly with respect to a material which may make considerable more pitch than that for which it was designed. Second, it can be used to produce either No. 6 fuel oil or a relatively small yield of unblended coke-like material; thus it is easily adaptable to changing market conditions.

Most of the data which have been given herein have pertained to Los Angeles Basin crude oil. This has been done because California may be the place where the greatest danger of overproduction of residual fuel oil exists. Most of the conclusions and trends which have applied to Los Angeles Basin crude oil apply also, in some measure, to other crude oils and particularly to those of West Texas, where much of additional experience is centered.

Catalytic cracking is less effective in raising gasoline yield and reducing No. 6 fuel oil in the case of California crude oil than with Texas and Mid-Continent stocks. In the latter cases, catalytic cracking tends to increase yields of intermediate distillates more than that of gasoline. The principal effect of deep feed preparation of all stocks appears also to result in increased distillate yields.

A desirable solution to this tendency toward unbalance would be to raise catalytic cracking conversion beyond the level of 50 to 55 percent which is generally used. This conversion is ordinarily limited by the cost of coke burning, and in some instances recycle has been introduced as a means of raising conversion within the limitations. Two-stage catalytic cracking is a much more potent tool for raising conversion economically; thus the combination of this plus deep feed preparation is especially desirable.

Table 3 illustrates the advantage of the combination of deep feed preparation and two-stage catalytic cracking over vacuum flashing followed by single-stage cracking. When yields are expressed on the basis of West Texas straight-run residue (SRR), it is clear that considerably higher gasoline production is achieved by flash cracking followed by two-stage catalytic cracking. At approximately the same coke make, two-stage catalytic cracking following deep feed preparation yields 10 percent more C_5 to 450-F. gasoline on the basis of straight-run residue. If the propylene and butylenes are polymerized, the advantage in gasoline yield is even greater.

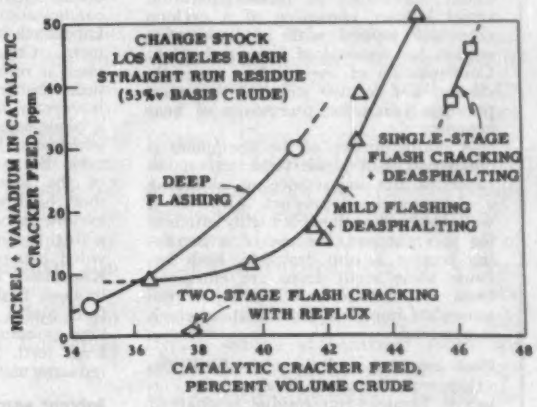

CHARGE STOCK
LOS ANGELES BASIN
STRAIGHT RUN RESIDUE
(53%v BASIS CRUDE)
NICKEL + VANADIUM IN CATALYTIC CRACKER FEED, ppm
DEEP FLASHING
SINGLE-STAGE FLASH CRACKING + DEASPHALTING
MILD FLASHING + DEASPHALTING
TWO-STAGE FLASH CRACKING WITH REFLUX
CATALYTIC CRACKER FEED, PERCENT VOLUME CRUDE

FIGURE 8 — In metals rejection there is a different order of effectiveness.

This, then, appears to be the best pattern for future refinery construction: to reduce gradually production of No. 6 fuel oil and to maintain relatively high gasoline yield by combining deep feed preparation—such as flash cracking—with two-stage catalytic cracking. This combination makes maximum use of a catalytic cracking process operated in its most effective manner.

Original presentation was before the American Petroleum Institute, Division of Refining, Los Angeles, May 13, 1958.

ACKNOWLEDGMENTS
Experimental work serving as the basis for this

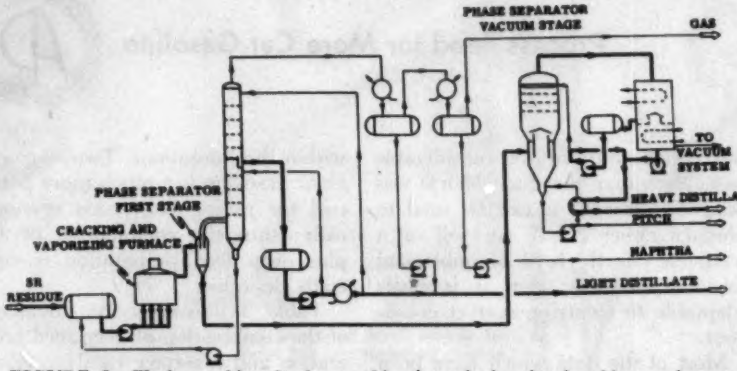


FIGURE 9—Flash cracking is the combination of viscosity breaking and vacuum flashing.

In vacuum flashing a straight-run residue, coming hot from the crude-oil distillation unit, is further heated in a furnace, where some of it is vaporized under vacuum. A phase-separation vessel follows, consisting of a cyclone separator topped with a disengaging section for removal of entrained pitch. Condensation of overhead is generally carried out in two steps at two temperature levels for purposes of heat economy.

A major portion of the equipment is concerned with phase separation because of the importance of obtaining a clean overhead product. Although a well-designed cyclone is highly efficient for this purpose, the use of a rectifying section is also desirable, both because some small drops are entrained from the cyclone and because of the somewhat improved fractionation which is obtained.

Flash cracking as designed by Shell Development Company is shown in Figure 9. Straight-run residue is charged to a furnace having a contact time of only a few seconds and a transfer temperature of approximately 925 F. This material enters a small cyclone separator at a pressure of approximately 30 psig. The vapor from the cyclone separator enters a column where partial condensation takes place and some knockback is created to reduce entrainment. Overhead condensation equipment is similar to that used in the vacuum flasher. Liquid from the cyclone is vacuum-flashed without reheating in a phase-separation vessel, at a pressure which may be as low as 20 mm of mercury. Because of the high temperature of the first-stage flash, an extremely short holding time for the liquid in the cyclone is necessary and thus a rapidly acting liquid-level control valve is provided between the two flashing stages. Knockback material for de-entrainment in both flash stages is returned to the feed, and a recycle is introduced which may amount to 10 to 20 percent of the fresh feed. This recycle is effective in reducing metals contamination.

Solvent extraction of vacuum-flasher pitch has been advocated primarily by The M. W. Kellogg Company and is called "solvent decarbonizing."[3] It is similar to the propane deasphalting of lubricating oils, the chief difference being that it utilizes a relatively low solvent-oil ratio and, in some cases, a mixture of propane and butane as solvent. For this process, pitch from a vacuum flasher is prediluted with solvent and charged to a contact tower where a countercurrent flow of the remainder of the solvent is introduced. With careful attention paid to both the temperature of extraction and the temperature profile, separation is achieved between the overhead extract and the asphaltic raffinate, both of which are heated for removal of solvent by flashing. Successive flashing stages are provided.

Delayed coking utilizes a cracking furnace followed by a large vessel where flash separation and soaking take place. The liquid remaining in the vessel reacts to coke; usually several vessels are used in alternate filling and cleanout periods.

Fluid coking has been extensively described.[6] Feedstock, consisting of flasher pitch, is dispersed in a bed of finely divided fluidized coke maintained at a sufficiently high temperature to cause rapid reaction and vaporization. The time of reaction is shorter and the pressure is lower than in delayed coking; as a result, higher distillate yields of better quality and lower coke and gasoline yields are obtained. Furthermore, heavier feedstocks may be charged, so that the capacity of the relatively expensive coking facilities need not be so great. The coke is circulated between the reactor and a coke burner, where heat is provided for the process. In the condensation and fractionation equipment a knockback is used to introduce a recycle; this feature aids in reducing entrainment of heavy ends and coke and results in improved metals separation.

TABLE 3

Comparison of Feed-Preparation and Catalytic Cracking Processes for West Texas Feed

Feed-Preparation Process:	VACUUM FLASHING			FLASH CRACKING	
Catalytic Cracking Process:	Single-Stage	Single-Stage	Two-Stage	Single-Stage	Two-Stage
Feed to catalytic cracking, basis SRR, percent by volume	66.0	66.0	66.0	86.7	86.7
Conversion basis of cracking feed (100 minus percent by weight of 450 + F material)	52.2	65.3	67.5	61.8	67.4
Recycle ratio*	1.8	2.2	1.8	2.0	2.0
Yields, basis SRR, percent by volume †:					
Coke†	2.6	4.8	3.3	4.7	4.8
C_5 to 450-F gasoline	27.3	32.1	33.0	42.2	42.7
C_3 =	2.7	2.9	5.1	3.8	6.1
C_4 =	3.5	3.0	6.5	4.1	7.9
Polymer gasoline from olefins	4.5	4.3	8.5	5.8	10.3
Total gasoline	31.8	36.4	41.5	48.0	53.0

* Volumetric recycle ratio defined as total feed to all stages divided by fresh feed to first stage.
† Coke yield only is in percent by weight.

paper was performed at the Houston Research Laboratory of the Shell Oil Company, and at the Emeryville Research Center of the Shell Development Company.

LITERATURE CITED

[1] J. C. Dart, G. A. Mills, A. G. Oblad, and C. C. Peavy, "Houdresid Converts Crude Residua Into Profitable Products," *Oil Gas J.* 54 [1] 123-6 (1955).
[2] H. A. Brown and M. J. Sterba, "Raw Crude Oil Is Charged Directly to 2,600 B/D Catalytic Cracking Unit," *Petroleum Processing* 4 [8] 878-80 (1949).
[3] *Kelloggram No. 3.* The M. W. Kellogg Co., New York (1956).
[4] R. Maass and R. E. Lanterbach, "Delayed Coking Unit Processes Residuum Into Gas Oil Charge for FCC Unit," *Petroleum Processing* 2 [1] 11-16 (1947).
[5] D. T. Thornton, Jr., "Why Carter Likes Coker," *Petroleum Processing* 10 [6] 840-5 (1955).
[6] G. Weber, "Refiners Will Have Coke to Burn," *Oil Gas Journal* 54 [14] 62-5 (1955).

About the Speaker

Dr. W. V. Medlin graduated from the University of California and received a Ph.D. degree from the California Institute of Technology in 1935. He then joined Shell Oil Co., as a technologist, and since 1946 has been associated with Shell Development Co. There he worked in the design and evaluation of oil processes. At present he is a supervisor in the Oil Process Engineering department at Emeryville, Calif.

Gasoline From a Liquid Poly Catalyst

Equipment is available now to use liquid phosphoric acid to polymerize propylene or mixed propylene-butenes feed. See how this new process works.

E. D. Kane and G. E. Langlois
California Research Corporation
Richmond, Calif.

THIS new process for polymerizing a propylene or mixed propylene-butenes feed uses phosphoric acid as the catalyst, but in unsupported liquid form rather than in a conventional fixed bed. The hydrocarbon feed and the acid catalyst are contacted in a novel, high-efficiency, orifice-plate reactor. The main advantages of the process are excellent temperature control, high olefin conversion, simplified product recovery, and high operating factor because of the ability to replace spent catalyst without plant shutdown.

The potential advantages of a liquid catalyst have been recognized for many years but could not be realized until commercial equipment became available at competitive costs for withstanding liquid phosphoric acid corrosion at the required acid strength and temperature. A suitable alloy was found, and commercial fabrication techniques were worked out recently which made it possible to develop the process.

Use of liquid phosphoric acid results in much smaller reactors than for fixed-bed processes. Because of this and other features, higher design conversions are economical. The smaller reactor-section equipment also means savings in site costs, particularly since no site facilities are needed for loading and unloading solid catalyst-support materials.

The typical process flow is shown in Figure 1. The liquid phosphoric acid catalyst is brought into intimate contact with the hydrocarbon feed in a small, high-efficiency reactor. The hydrocarbon polymer and acid from the reactor are separated in a conventional settler vessel, and the acid is returned to the reactor through a cooler. The product stream goes to the recovery section to yield a polymer gasoline with the desired vapor pressure. Caustic scrubbing of the hydrocarbon from the settler is provided as protection for the recovery equipment in the event of inadvertent acid carryover. In normal operation, all of the acid is removed from the polymer product in the settler, and caustic consumption is negligible. The acid stream which is returned from the settler to the reactor provides a high heat-capacity "fly wheel," so that the temperature rise in the reactor is relatively small and reactor-outlet temperatures can be readily controlled within narrow limits.

Feed to the plant may be a gas or liquid stream containing propene or butenes or mixtures of both. The feed is caustic-washed for the re-

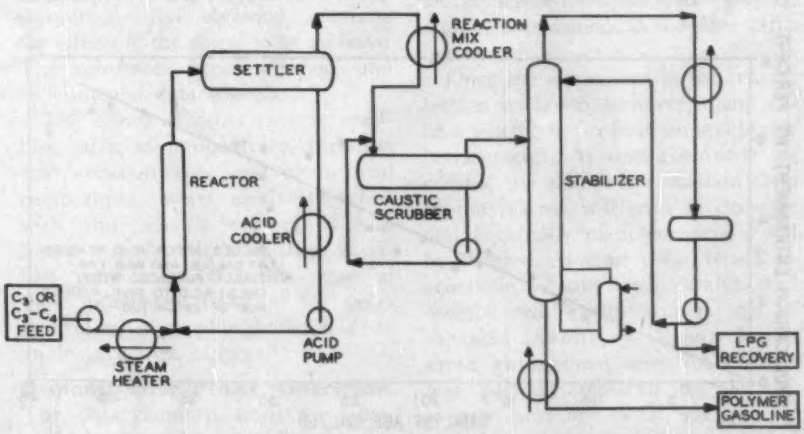


FIGURE 1—The design advantages of a liquid catalyst can be obtained now because commercial equipment is available to withstand the corrosion.

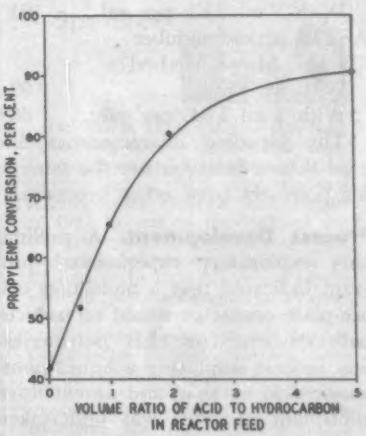


FIGURE 2—Greater olefin conversion is achieved with increased acid rate.

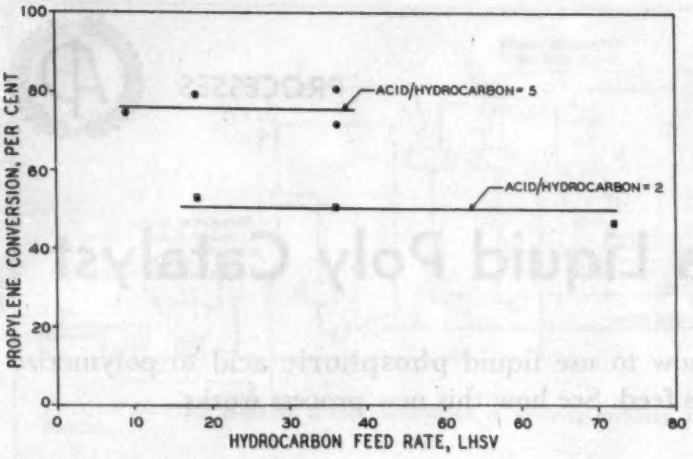


FIGURE 3—Variation of the feed rate by a factor of 4 caused a negligible change in the olefin conversion.

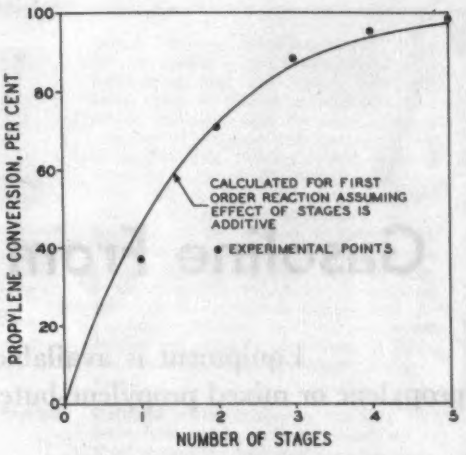

PROPYLENE CONVERSION, PER CENT
NUMBER OF STAGES
CALCULATED FOR FIRST ORDER REACTION ASSUMING EFFECT OF STAGES IS ADDITIVE
• EXPERIMENTAL POINTS

FIGURE 4—The agreement between theory and experimental data was good.

moval of hydrogen sulfide (H_2S) and mercaptans and water-washed for removal of nitrogen compounds.

Product Characteristics. The gasoline polymers produced by the bulk acid process are similar to those from commercial fixed-bed processes. For example, some inspections of typical, debutanized bulk acid motor polymer from a mixed propene-butene feed are shown in Table 1.

Table 1

Debutanized Polymer Gasoline	
Gravity, deg API	59.5
ASTM Distillation Method D 86, deg F:	
Initial boiling point	132
10-percent point	206
50-percent point	271
90-percent point	372
End point	439
ASTM octane number (D 908, Research Method):	
Without TEL	96.8
With 3 ml TEL per gal	101
ASTM octane number (D 357, Motor Method):	
Without TEL	82.5
With 3 ml TEL per gal	86.0

The blending characteristics and road-octane behavoir are the same as for polymers from other processes.

Process Development. A preliminary exploratory experimental program indicated that a multistage orifice-plate contactor would be particularly efficient for this polymerization process employing a liquid phosphoric acid catalyst, and an extensive pilot-plant program was undertaken to determine the effect of process and reactor design variables on the rate of reaction. Most of this study was carried out with a propylene-propane fraction as feed, although data were also obtained with C_4 and mixed C_3 and C_4 feeds.

Effect of Acid-to-Hydrocarbon. The reaction can be carried out by filling the reactor with acid and jetting the hydrocarbon into the acid through an orifice located at the bottom of the reactor. In this type of operation the minor amount of acid entrained with the reaction mixture is separated in the settler and returned to the reactor. However, it was found that if acid is circulated through the reactor together with the hydrocarbon feed, the olefin conversion increases with increasing acid-to-hydrocarbon ratio. This effect may be seen in Figure 2, which shows that as the volume ratio of acid to hydrocarbon in the reactor feed increases from zero to 5, the conversion increases from 40 percent to 90 percent. This effect is the result of the increased intimacy of contact between the two phases while passing through the orifice, because in a single-stage reactor no increased rate of reaction was obtained when the acid was introduced in a separate stream above the orifice plate.

Effect of Feed Rate. An unusual feature of this type of contacting system is that the olefin conversion is nearly independent of the feed rate. If other variables are held constant and if the acid-circulation rate is changed together with the hydrocarbon-feed rate in order to hold the acid-to-hydrocarbon ratio in the reactor feed constant, the olefin conversion remains constant. This effect is shown in Figure 3. Variation of the feed rate by a factor of 4 caused a negligible change in the olefin conversion. As the feed rate is increased, the pressure drop across the orifice plate increases, with a consequent in-

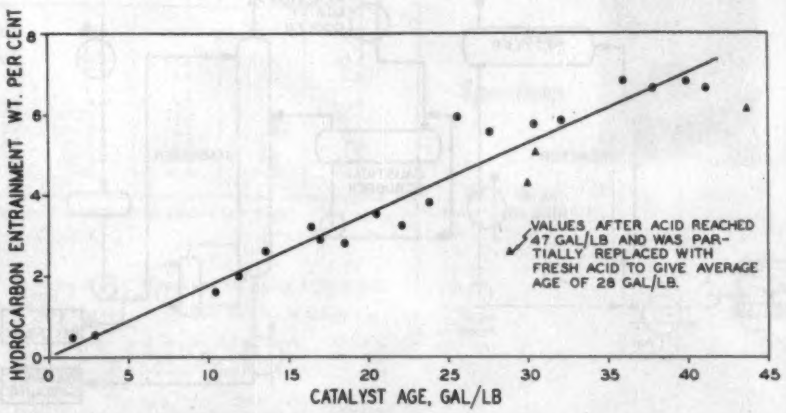

HYDROCARBON ENTRAINMENT WT. PER CENT
CATALYST AGE, GAL/LB
VALUES AFTER ACID REACHED 47 GAL/LB AND WAS PARTIALLY REPLACED WITH FRESH ACID TO GIVE AVERAGE AGE OF 28 GAL/LB.

FIGURE 5—There is no decline in catalyst activity; however, entrainment will reduce the acid-to-hydrocarbon ratio.

crease in power input. It appears that the improved contact between the two phases resulting from the increased power input just compensates for the reduction in residence time in the reactor.

Effect of Number of Stages. For any given stage and orifice-plate configuration, the olefin conversion can be increased by passing the reactants through a number of stages in series. A typical multistage reactor consists simply of a vertical tubular reactor shell with a number of perforated plates installed at spaced intervals. The polymerization of propene over

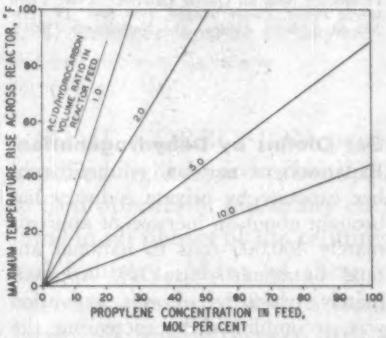


FIGURE 6—Reactor temperature rise can be limited to less than 50 F. Here are data for adiabatic temperature rise across a reactor with a propylene-propane feed.

phosphoric acid supported on an inert solid has been found to follow first-order reaction kinetics,[1] and it was found that our data with multi-stage reactors could be correlated readily with a first-order rate equation, assuming the effect of additional stages to be additive.

This can be seen in Figure 4, where data are shown for a reaction with five stages in series. Reaction mixture was sampled at the outlet of each stage and the data compared with the theoretical curve obtained, assuming the effects of the stages to be additive. The agreement between theory and experimental data was good.

The effects of other process variables, such as temperature, pressure, acid concentration, and olefin feed composition, were also established with this reactor system. It was found that the effects of these variables were essentially the same as those previously reported for polymerization with phosphoric acid on an inert quartz support.[2]

Demonstration-Plant Operation. The data obtained from the pilot-plant investigations, highlighted previously, gave a basis for designing a nominal 100-barrel-per-day feed-rate demonstration plant. This plant was located in the Richmond refinery of the Standard Oil Company of California and operated from refinery feedstreams, so that the feed was subject to the variation in composition and treating that are typical of commercial operation.

After an initial series of shakedown tests, the plant was operated continuously for more than 3,000 hours at feed rates up to 125-barrels-per-day to obtain information on catalyst life and effect of catalyst age on performance. Conversions of 95 to 98 percent were obtained with either propene or mixed propene-butene feeds with both new and aged acid. Catalyst age was carried past 45 gal. of polymer produced per pound of acid, and partial replacement of the acid was done routinely without interrupting plant operation.

Unlike fixed-bed catalyst plants, there was no apparent decline in catalyst activity as the acid aged in the bulk acid plant. In fact, under some conditions a slight increase in conversion was noted as the catalyst aged. The eventual limit on economic catalyst life would be set by the phenomenon illustrated in Figure 5. As catalyst life increases, the hydrocarbon entrainment in the acid stream recycled from settler to reactor increases. The magnitude of the entrainments shown in Figure 5 depends on reactor section and settler design. For example, later tests with longer settler-residence times showed a lower entrainment at the same catalyst age.

Once the equipment in the reactor section is chosen, however, there will be a specific upper limit on acceptable entrainment. As entrainment increases, the acid-to-hydrocarbon ratio in the reactor will tend to decrease and eventually plant conversion will be affected. At some point, it will be economic to add fresh catalyst and thereby reduce the average age of the acid inventory. Figure 5 also shows entrainment after the catalyst was partially replaced to give an average acid age of 28 gal. per lb. and then operated again to an age of approximately 44 gallons per pound. The entrainment behavior was comparable to that observed with the original acid charge.

It is particularly significant that the "old" acid could be partially withdrawn and replaced with fresh acid without shutting the plant down. This procedure was repeated routinely during the demonstration-plant operation and makes possible a high operation factor in a commercial plant.

Temperature control in this plant was excellent, and the maximum temperature at the reactor outlet was maintained within ±3 F with conventional control instrumentation. The main reason for easy temperature control is the relatively high heat capacity of the recycled acid stream. Figure 6 shows the calculated temperature rise through a bulk acid process reactor for 100 percent olefin conversion. Although selection of the best acid-to-hydrocarbon ratio for a particular feed situation requires an economic study, it will be apparent from Figure 6 that the reactor temperature rise can be limited to less than 50 F.

Materials of Construction. A series of screening experiments on the corrosion resistance of various metals

About the Speaker

Dr. Eneas D. Kane has B.S. and Ph.D. degrees in mechanical engineering from the University of California, and a M.S. degree from Kansas State College. From 1940 to 1951 he was on the staffs of the Department of Engineering and the Radiation laboratory, University of California. In 1952-53 he was supervisor of process design and evaluation for California Research and Development Co. on Atomic Energy Commission Projects. He has been with California Research Corp. since 1954 as a technical specialist on various process design and research problems. He is currently a senior engineering associate.

and alloys showed that one commercial nickel-molybdenum-iron alloy (A.S.M.E. Code U.P.V. Case 1173) had good corrosion resistance under the acid strength and temperature conditions used in the process. In order to use the less expensive carbon steels as structural materials in the reactor and settler vessels, the techniques for cladding the alloy on carbon steel and for performing the necessary welding operations were worked out. The settler vessel in the demonstration plant is 1½ feet ID by 4 feet long and was constructed from carbon steel with a 12-gage thickness of alloy integral cladding. Corrosion rates in this vessel were found to be less than 1 mil (0.001 inch) per year when it was opened up at the end of the operating period described previously.

The acid recycle pump is a centrifugal pump made from the same alloy. The pump was equipped with a standard mechanical seal which gave satisfactory service after development of suitable materials for the wearing surfaces. The lines and valves in contack with liquid acid were made from the alloy, and corrosion experience here was satisfactory, with the exception of the valve trim which also required modification.

From the considerable background of experimental work plus equipment performance in the demonstration plant, it can be concluded that satisfactory materials of construction and fabrication techniques are available for commercial-scale bulk acid process plants.

Original presentation was before the American Petroleum Institute, Division of Refining, Los Angeles, May 13, 1958.

LITERATURE CITED

[1] S. R. Bethea and J. H. Karchmer. "Propylene Polymerization in Packed Reactor-Liquid Phosphoric Acid Catalyst." *Ind. Eng. Chem.* 48 [3] 370-77, March (1956).

[2] G. E. Langlois and J. E. Walkey. "An Improved Process for Polymerization of Olefins with Phosphoric Acid on Quartz Catalyst." *Proc. Third World Petrol. Congr. Hague, 1951* Sect. IV, 191-200, E. J. Brill, Leiden, The Netherlands (1951).

More About Processes

Unifining Has Many Uses. Increasing numbers of refiners are employing Unifining to upgrade various refined stocks and to improve the results from further processing steps. A wide variety of commercial operations now confirm the excellent results previously predicted by laboratory and pilot plant investigations.

Stocks other than naphthas which have been successfully Unifined in commercial installations include kerosines, burning oils, diesel fuel and distillates from coking and thermal cracking, as well as virgin gas oils. Principal benefits from Unifining these various refined products include desulfurization, improved color and storage stability, and better odor. The net effect thus is increased customer acceptance and improved competitive position.

Unifining of catalytic cracking feed stocks—virgin atmospheric and vacuum gas oils and likewise coker gas oils—shows dramatic benefits in the quality of the resulting products. Sulfur contents are reduced and leaded octane ratings of the cracked gasolines are increased. Conradson Carbon and heavy metals contents also are reduced, with resulting savings in catalyst cost.

("Commercial Unifining of Distillates and Gas Oils," C. F. Gerald and L. O. Stines, Universal Oil Products Company, Des Plaines, Ill.)

Union Oil Company of California has developed operating cost information on Unifining from a refiner's viewpoint, from its own operations and those of others. Of particular interest is the exceptionally low catalyst cost which becomes more outstanding when compared with other catalytic processes.

("Unifining—Some Operating Cost Experience", W. J. Baral, L. R. Damskey, Jr., and G. W. Hendricks, Union Oil Company of California, Los Angeles, Calif.)

Motor Fuels Require Special Processes. The recent trend is toward the manufacturing of gasolines containing an increased concentration of high-purity chemical grade hydrocarbons.

Traditionally, the production of petrochemicals and the production of motor fuels have been considered to be two separate branches of the petroleum refining industry. It now appears the motor fuel manufacturing facilities of the refinery of the future will produce chemical grade components for use both as motor fuel and as petrochemicals. This will permit the refiner more flexibility in his control of motor fuel quality and the extent of his participation in the petrochemical market.

Data now show the chemical composition of refinery pool gasolines and the sequence of installation of the basic refining processes of reforming, isomerization, alkylation, and solvent extracting to produce the highest quality motor fuel.

("Trends in the Production of High Quality Motor Fuels," Davis Read, M. J. Sterba, and Nellson R. Adams, Universal Oil Products Company, Des Plaines, Ill.)

Get Olefins by Dehydrogenation. Expansion of national synthetic rubber capacity by private industry has brought about an increase of approximately 400,000 tons in national annual butadiene capacity. Approximately two-fifths of this expansion was accomplished by increasing the capacity of existing facilities. More than 60 percent of the new butadiene capacity, or 250,000 tons annually, is accounted for by six entirely new plants, all of which were first placed in commercial operation during 1957.

All of the six new plants use the Houdry Dehydrogenation Process. The Houdry fixed-bed, multi-reactor, single-step process employs a chromia-alumina catalyst to convert plentiful and relatively inexpensive normal butane feedstock to butadiene (for SBR, synthetic textile fibres, paint and petrochemical applications), to butenes (for aviation alkylate), or to produce both products concurrently in desired ratios.

Material balances are given for commercial operation for production of butadiene and butenes as single end-products, and for dual-purpose production, together with pilot plant runs showing close correlation with commercial results. Laboratory data also are given for production of isoprene, isobutene, propylene, and styrene from appropriate charge stocks by this versatile, commercially proved catalytic process.

("Houdry Dehydrogenation for Olefin Production", Lee Friedman, Donald H. Stevenson and D. E. Womeldorph, Houdry Process Corporation, Philadelphia.)

How Phillips Solved Six Gas Plant Corrosion Problems

J. S. Conners and C. L. Seyer
Phillips Petroleum Company
Bartlesville, Okla.

SOME CORROSION problems in plants handling light-hydrocarbon liquids are peculiar to that operation, but many encountered are the same in all phases of the refining and petrochemical industry. Many of these problems can be solved successfully with a minimum of laboratory work and with very little field testing.

The practical aspects of six commonly occurring corrosion problems will be discussed including a remedy for each. This is not intended to be a detailed report of each problem but only the highlights including the difficulties encountered and the results achieved.

Aqueous Amine Treaters

PROBLEM: In 1947 it was necessary to construct a treater to remove hydrogen sulfide (H_2S) from a large volume of gas in order to complete a sale to a gas-transmission company. In view of our previous experience and that of others, as exemplified by the numerous articles written concerning corrosion in such treaters, the problem of potential corrosion was a matter of considerable concern.

DIAGNOSIS: In the design of amine treaters, it should always be assumed that the circulating solution will be corrosive to some extent. Amines oxidize readily and the oxidation products are extremely corrosive. Amines are not stable at elevated temperatures, tending to decompose, and the products of decomposition are very corro-

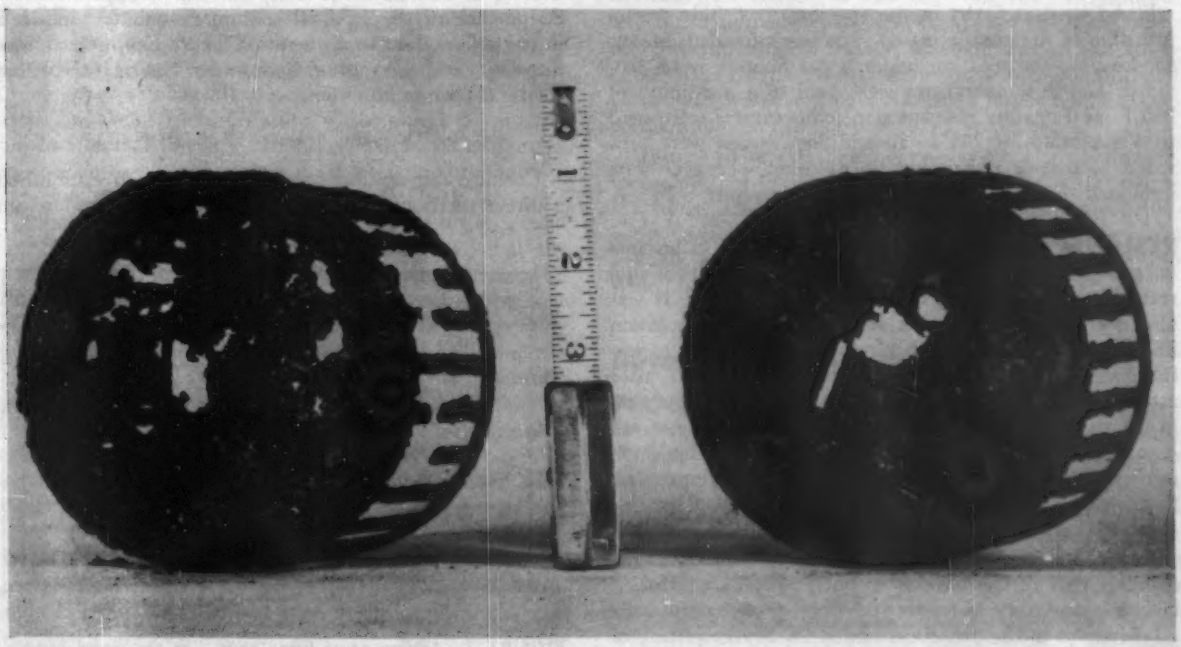


FIGURE 1—Fifty percent of the amine still's bubble caps were replaced because of this severe pitting type corrosion.

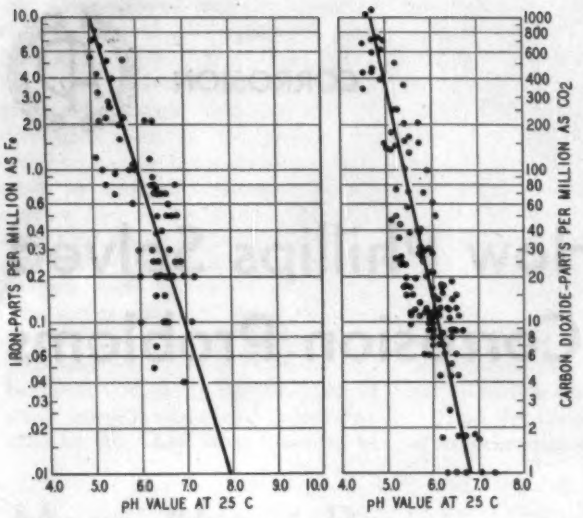


FIGURE 2—Test data show a direct relationship between iron content, CO_2 content and pH.

sive. These two characteristics of the amines used for gas treating made it imperative that every precaution be taken in both the plant design and operation to:

- Protect the solution from any contact with air.
- Prevent excessive temperatures.
- Provide a means for the removal of corrosive compounds as they are formed.
- Design the plant mechanically to withstand a somewhat corrosive solution at all times.

REMEDY: The plant was designed on the foregoing basis; and, except for the bubble caps, was constructed entirely of carbon steel. The absorbers and stills were stress-relieved. However, because of an oversight in construction, the shells of the still kettles were not stress-relieved as designated in the specifications. Side-stream filtration of the circulating solution was provided. Means for keeping the solution under a gas blanket were provided. Kettle temperatures were held to a maximum of 245 F. and heating element skin temperatures were held to a maximum of 285 F. In addition, means were provided to permit reclaiming the solution whenever tests indicated the presence of corrosive compounds.

RESULTS: In the period from 1948 to 1953, it became necessary to stress-relieve the heat-exchanger heads and return bends to prevent stress-corrosion cracking. It was also necessary to replace a section of the foul-solution line between the heat exchangers and the still with prefabricated stress-relieved pipe. In addition, in 1953, after attempting several repairs to small stress-corrosion cracks in the shells of the still kettles and stress-relieving of the repairs locally, it seemed advisable to have the shells removed from service, stress-relieved, and reinstalled. Since stress-relieving these portions of the plant, no additional cracking has occurred in this equipment.

Since 1953, because of stress-corrosion cracking of the chimney ears in the removable bubble-cap assemblies, it has been necessary to repair and stress-relieve practically all chimneys in the absorbers and stills. Severe pitting of the 16-gage, Type 410 stainless-steel bubble caps has made it necessary to replace approximately 50 percent of all bubble caps. This type of attack is shown in Figure 1. Experiments are under way to determine whether a heavy, cast-iron cap or a thin (16-gage) Type 304 stainless-steel cap will be more economically serviceable than the Type 410 caps.

The only other corrosion encountered has been in the still overhead condensers. Because of general thinning of the tubes, it has been necessary to retube two of the six overhead condensers.

It has been necessary to place the portable reclaimer in operation twice, for periods of approximately 12 weeks each, when tests showed the presence of nitrogen compounds other than monoethanolamine in the solution.

It is believed that the precautions taken in the design and operation of this treater have been successful in preventing corrosion, inasmuch as all vessels, pumps, heat exchangers, lines, and valves originally installed are in service and apparently undamaged.

Steam Systems

PROBLEM: Several years ago, it was considered that corrosion in a steam and steam-condensate system was excessive. At that time, production of 250-psig steam averaged over 900,000 pounds per hour. In producing this steam, it was necessary to supply approximately 10,000 gallons per hour of make-up water to the system. This make-up water was softened in a two-stage, deaerating, hot-process, lime-soda-phosphate softener. Tests showed that the oxygen content of the softened make-up water and the produced steam was zero.

DIAGNOSIS: It was thought that the corrosion was caused by the carbon dioxide content of the produced steam. This CO_2 was formed within the boilers by the decomposition, at boiler temperature, of approximately 80 percent of the residual sodium carbonate contained in the softened make-up water. The Na_2CO_3 decomposes into CO_2 and the sodium hydroxide (NaOH) according to the following equation:

$$Na_2CO_3 + H_2O + \text{Heat} = 2\,NaOH + CO_2$$

Considerable testing provided data which established a direct relationship between the CO_2 content of steam

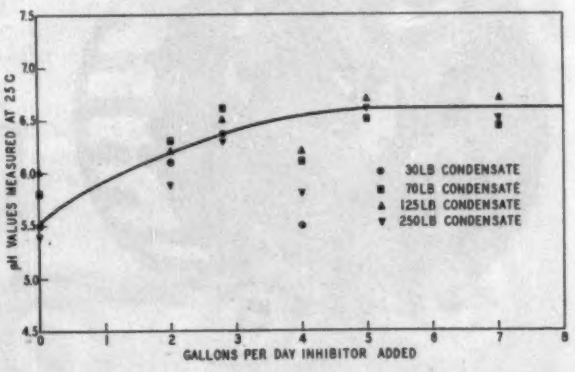


FIGURE 3—Adding neutralizing amines to the steam condensate raised the pH values and reduced corrosion in the system.

condensate, its iron content (corrosion product), and the pH. These data are shown in Figure 2. The average CO_2 content of the high-pressure (250 pounds) steam was approximately 10 ppm; and, as was expected, the CO_2 content of the exhaust steam was considerably higher and varied widely.

REMEDY: After reviewing the work of the Bureau of Mines on the use of neutralizing amines in steam boilers, it was decided to attempt to reduce the rate of corrosion by adding a small quantity of a blend of neutralizing, volatile amines to the boiler feedwater. Volatility characteristics determined the selection of a blend containing cyclohexylamine, benzylamine, morpholine, and dimethylethanolamine.

The effect on the pH of the steam condensate with varying quantities of the amine blend added is shown in Figure 3. These data indicated that the optimum effective protection would be afforded by the addition of 4 to 5 gallons of the blend per day or approximately 1.5 pounds per million pounds of steam produced.

RESULTS: The addition of the amine blend to the steam system in these proportions resulted in a 50 percent reduction in the man-hours spent in repairing kettle elements and a 60 percent reduction in man-hours spent in repairing and replacing small nipples and valves. Test coupons installed after use of the inhibitor was started show corrosion rates of 0.001 inch to 0.005 inch per year.

The results obtained by the addition of this type of inhibitor to a steam system have been so successful that its use has been expanded; and it is now being used in approximately 50 percent of Phillips' gasoline plants where a relatively high percentage of steam condensate in the boiler feedwater makes its use economical.

Cooling Tower Pipe

PROBLEM: The water-distribution piping in cooling towers, particularly in towers of the atmospheric type, is subject to severe external corrosion. This corrosion is often ignored because leaks in this piping can be tolerated, and even structural failure of the pipe is not usually a catastrophe. Even so, such failures can result in damage to the tower-fill material as well as reducing the efficiency of the tower.

Piping to hydrocarbon-cooling coils in a tower is subject to external corrosion which is most severe at the point of entry into the tower. Pitting corrosion rates on this pipe are as high as 0.125 inch per year. A buildup of mineral deposits resulting from the water evaporating on the hot piping often hides the corrosion which is occurring. Ordinary paint used for general plant painting is of little value in preventing this corrosion. Failure of this hydrocarbon piping would likely result in a fire with loss of the tower and other equipment. A hazard such as this, with a high corrosion rate, cannot be tolerated.

DIAGNOSIS: Cooling-tower water is essentially noncorrosive when properly treated. The absence of corrosion of tower hardware, which was constantly wet, supported the assumption that the water was noncorrosive. Therefore, it was concluded that the corrosion of both the water-distribution piping and the piping to the hydrocarbon cooling coils was the result of alternate wetting and drying under oxidizing conditions. In effect, this is simply atmospheric corrosion accelerated by warm, moist conditions.

REMEDY: For the water-distribution piping, copper-alloy materials were considered but quickly eliminated when compared with periodic replacement of steel pipe. Plastic pipe was then considered, with rigid polyethylene being selected as the most economical. The cost of rigid-polyethylene pipe is comparable to the cost of steel pipe except for the molded-polyethylene fittings. To avoid the use of these expensive fittings, welded construction is to be used except for the couplings used for connecting the spray nozzles.

The solution to the corrosion of the hydrocarbon coil piping was to apply an inorganic zinc-dust coating, and also to provide a $\frac{3}{16}$-inch corrosion allowance in all replacement pipe. The zinc-dust coating was selected after testing some 20 coatings in several towers during the past 10 years.

RESULTS: The first instalation of rigid-poyethylene pipe is being made at the present time. Accelerated laboratory-exposure tests are inconclusive to date, and this test installation will determine actual service life as compared with a life of 5 to 8 years for $\frac{1}{4}$-inch wall steel pipe.

The zinc-dust coating, on the coil piping, is providing protection for 2 to 3 years. The principal advantage of the zinc-dust coating is that only one coat is required, which usually permits application to existing piping without its removal from service. Minor difficulties of application have been overcome with experience. The $\frac{3}{16}$-inch corrosion allowance provides a safety factor which allows considerable latitude in scheduling recoating.

Testing of several new coating systems is continuing, including hot-sprayed applications and coal-tar-epoxy materials. These new systems appear particularly promising for a less severe service, such as hydrocarbon headers which are not subject to continual spray and which operate at a maximum of 180 F.

Butane Isomerization Units

PROBLEM: In 1943 when the design of the company's catalytic, vapor-phase, butane-isomerization unit was started, (Editor's Note: See September, 1956, PETROLEUM REFINER, p. 253 for process description) there was very little corrosion data on the process. As the result of one year of operation of a similar unit, it was known that corrosive conditions could be expected in the reactor and hydrogen chloride stripper portion of the unit. As the unit was to be built during the war, it was desired to use no more alloy equipment than absolutely necessary. However, it was premised that the unit must operate,

corrosion-wise, for at least six months between turnarounds.

DIAGNOSIS: Conversion of *n*butane to *iso*butane is accomplished by utilizing aluminum chloride as a catalyst. The activity of the catalyst is greatly increased by the addition of anhydrous HCl. The $AlCl_3$ also promotes undesirable reactions with sulfur, olefins, and other feed and catalyst impurities to form a sludge, which becomes corrosive in the presence of HCl. Also, it was concluded that traces of water could be expected in the unit even though the feed was to be dried.

REMEDY: The decision was made to use corrosion-resistant materials only for the equipment in which the most severe corrosion was expected. Carbon-steel equipment in the corrosive portion of the unit was provided with a corrosion allowance, and yearly replacement of some pipe was anticipated.

Process design considerations which contributed to corrosion control were as follows:

- Three feed driers were provided; two onstream, in series, and one on regeneration.
- Guard chambers were provided to protect the equipment downstream from the carry-over of $AlCl_3$, bauxite fines, and corrosive sludge.
- A drying system was provided to thoroughly dry the equipment with hot butane after turnaround washing.
- A butane flush system was provided to continuously purge the packing glands of pumps.

RESULTS: Corrosion in the unit has been somewhat more severe than anticipated, with a break in the corrosion-thinned piping between the guard chambers and effluent condensers causing a fire. Subsequent to this fire, a system of tell-tale holes was devised to supplement the interial inspection made during semiannual turnarounds. These ⅛-inch-diameter tell-tale holes were drilled, on 18-inch spacing, to a depth equal to the metal thickness required for pressure, leaving the corrosion allowance undrilled. Leakage of a tell-tale hole indicates that the corrosion allowance has been consumed. The hole is then plugged with a tapered steel pin and operation continued until the next planned turnaround. Corroded pipe is now replaced when the maximum permissible metal loss is indicated by tell-tale holes, sonic inspection, or visual observation. The average life of steel pipe in the corrosive portion of the unit is three years.

The 1½-inch concrete lining in the pretreaters has required replacement at four-year intervals, but has satisfactorily protected the vessels. The lining in the reactors has required some maintenance, and has corroded an average of 1/32 inch during 15 years. Glassed-steel vessels are being considered for replacement of the reactors. The seamless-steel tubes originally used in the effluent condensers have been replaced with monel tubes, and the design of the condensers has been changed to utilize monel-faced, double-tube sheets. The bottom portion of the stripper feed tank has been subject to severe corrosion. This corrosion has been controlled by providing a ½-inch-thick bottom lining and by sloping the vessel for positive drainage to external drain pots.

Process changes which have aided corrosion control are as follows:

- Reactor-temperature limits, both high and low, have been established to minimize sludge formation.
- A better drying procedure, including HCl curing of the catalyst beds, has been devised to assure more effective water removal after turnarounds.
- More efficient treatment of the feed, removing practically all of the sulfur, has resulted in less sludge and corrosion.

Gas Transfer Lines

PROBLEM: Corrosion was excessive in a 2-inch raw-gasoline line, which was 11,000 feet in length. The line was installed in 1946, and by 1955 an average of 50 leaks per year required repair. Pressure drop was excessive and frequent scraping (every two weeks) was required in order to permit transfer of the plant's production with a 500 psig pump-discharge pressure. The fluid end of the transfer pump required extensive repair including new liners and pistons each six months. It also required packing at least once each week, and sometimes it was necessary to repack as often as twice a day.

DIAGNOSIS: The gas to the absorption plant contained hydrogen sulfide, carbon dioxide and air. It was assumed that all of these molecules would be present in the gasoline in some quantity. It was known that the gasoline was water-saturated and also contained some entrained water.

REMEDY: It was decided to try to minimize the corrosion by the use of an inhibitor. The inhibitor selected was a salt of an imidazoline and a high molecular-weight organic acid. These inhibitors are of the film-forming type. Prior to injection of the inhibitor, test coupons were placed in the line to determine the base rate of corrosion. After the base rate was found, the rate of corrosion with inhibitor injection at rates of 18 ppm and 12 ppm was determined. The results of these tests are shown in Table 1. From these data, inhibitor injection at the rate of 12 ppm appeared to be adequate.

TABLE 1—Corrosion Rate in Sour-Gasoline Line

	Before Treatment	Treatment With 18 PPM Inhibitor	Treatment With 12 PPM Inhibitor	
	10-11-55 to 11-22-55	1-30-56 to 3-22-56	3-22-56 to 4-16-56	4-16-56 to 6-11-56
Air Content of Inlet Gas, Mol Percent	....	3.3	1.7	1.3
Corrosion Rate in Mils per Year	6.4	6.3	6.2	4.2

It was considered desirable that inhibitor injection be continuous. This was difficult, inasmuch as the daily quantity required was only one-fourth of a gallon. Tests showed that the material could be diluted with the kerosine used as plant absorption oil in the proportion of one volume of inhibitor to six volumes of kerosine. At a greater dilution rate, the inhibitor would not stay in solution.

RESULTS: As a result of injection of this inhibitor at a rate of 12 ppm, pump-discharge pressures have declined

from 500 psig to 300 psig. Frequency of line scraping has declined from biweekly to a semiannual basis and no corrosion product is found in the scraper traps after scraping. The transfer pump requires packing at 5- to 6-month intervals. The fluid end of the pump has been in operation more than 18 months without repair or liner replacement.

The results obtained with this type of inhibitor have been so successful that its use has been expanded. It is now protecting several hundred miles of sour-gasoline gathering lines.

Product Storage Tanks

PROBLEM: Corrosion in atmospheric finished-product tanks in Phillips' natural-gasoline operations has been recognized as a serious problem within the past five years. Both exterior and interior corrosion of tank roofs has been an expensive replacement problem. Interior corrosion of tank bottoms in this service is not a problem; however, external corrosion of the bottoms has been severe. Metal loss on the shell of a tank is more serious, and to continue the use of a tank with severe shell corrosion requires a decision to either exceed the allowable stress, limit the filling depth, or rebuild the tank.

The corrosion rate of the shells in product storage tanks has been found to range from 0.001 inch per year to as high as 0.016 inch per year. Considering all measurements made on some 40 tanks (both cone-roof and floating-roof), 20 percent of the tanks had shell corrosion rates greater than 0.005 inch per year and 80 percent had corrosion rates less than 0.005 inch per year. Therefore, it can be concluded that 80 percent of the tanks considered could have had a safe predicted life if they had been constructed with a corrosion allowance of 0.005 inch per year of desired life.

DIAGNOSIS: Corrosion of the exterior surface of tank roofs is serious only on water-sprayed cone roofs, where failure of normal paint systems is rapid. Condensation of water on the inside surfaces is the primary cause of internal corrosion in cone-roof tanks. In addition, floating-roof tanks also are subject to metal loss on the shell as a result of the abrasive action of the roof seal shoes. Corrosion in both types of tanks will vary with the frequency of filling and emptying. External corrosion of the tank bottom is caused by the difference in electrical potential between the tank bottom and ground. The rate of such corrosion varies with the electrical resistance of the soil.

REMEDY: An inorganic zinc-dust coating is being used to protect the water-sprayed cone roofs. For reflectivity, one coat of mildew-resistant white paint is used over the zinc-dust coating. To control internal corrosion of both cone and floating roofs, ¼-inch roof plates are used instead of the standard 3/16-inch plates.

Cathodic protection is used to protect the exterior of tank bottoms. In order to minimize the cathodic protection requirements, a sand pad is used under tanks, and adequate facilities are provided for drainage of surface water.

The protection of the interior of tank shells with a paint or coating is generally considered as uneconomical. However, epoxy-resin and zinc-dust coatings have been used to stop further shell corrosion after the minimum safe thickness has been reached. In arriving at a minimum thickness for retirement, recent practice has been to consider that corrosion allowance is available in a standard API 12C tank when it is used for storage of a product with a specific gravity less than 1.00. *Example:* A 55,000-barrel tank, 40 feet high and 100 feet in diameter, would have a corrosion allowance of 0.08 inch when used with a product of 0.75 specific gravity. This same premise is used for the design of new tanks; i.e., the shell thickness is designed for a 0.75 specific-gravity product, and a thickness equal to 0.005 inch per year of desired life is added for corrosion allowance. Table 2 illustrates this design premise.

TABLE 2—Shell Thickness for 55,000-Barrel Atmospheric Tank

	SHELL RING FROM BOTTOM				
	1	2	3	4	5
Standard API 12-C Shell Thickness, Inches (to Next 1/32 inch)	.59	.47	.34	.25	.25
Calculated Thickness Req'd for 0.75 Sp. Gr., Inches	.44	.35	.26	.17	.08
Corrosion Allowance, In. 12-C Tank, 0.75 Sp. Gr.	.15	.12	.08	.08	.17
Thickness Req'd., in. for 0.75 Sp. Gr. Plus 0.100 Corr. Allow. (to Next 1/32 In., with ¼ In. Min.)	.56	.47	.37	.28	.25
Comparison of Proposed and Standard 12-C Thickness	−1/32	Same	+1/32	+1/32	Same

RESULTS: The zinc-dust coating on water-sprayed cone-roof tanks is providing 2 to 3 years of protection against external corrosion. The use of ¼-inch steel plates for the roof is providing a roof life of 10 to 12 years before replacement is necessary as a result of internal corrosion. Cost studies have confirmed that the use of ¼-inch plates to combat internal corrosion is more economical than the use of thinner plates with coatings.

Cathodic protection is providing complete protection

About the Speaker

Chester L. Seyer, of Phillips Petroleum Co., graduated from the University of Oklahoma in 1943 with a B.S. degree in mechanical engineering. He joined Phillips in 1946, working in the Mechanical and Metallurgical section of Phillips' Plains Butadiene plant near Borger, Texas. In 1947 he transferred to the Gasoline department in Bartlesville to work on special problems in the Engineering and Construction division. He is now a supervising metallurgical engineer in the Gasoline department and is a registered professional engineer.

against external corrosion of tank bottoms. Coating the exterior of the tank bottom with a bituminous or thick, plastic coating has reduced the cathodic protection requirement, but coating without cathodic protection is unsatisfactory. Glassed-steel plates are also being evaluated for use with cathodic protection to combat external corrosion of tank bottoms.

Original presentation was before the API Division of Refining Meeting, Los Angeles, May 12, 1958, under the title "Solutions to Corrosion Problems in Light-Hydrocarbon Liquids Plants."

ACKNOWLEDGMENT

The authors wish to express their thanks to Phillips Petroleum Company and the personnel who contributed material and constructive criticism during the preparation of this paper.

More About Corrosion

What Fe-H_2S Does at High Temp. The iron-hydrogen sulfide reaction was investigated in the range of 427 C. to 760 C. The following observations were made:

a. The law of attack is linear.

b. The rate depends markedly on the partial pressure of hydrogen sulfide but not on the pressure of hydrogen which acts merely as a diluent; hydrogen can be replaced by helium at the same partial pressure, the rate remaining unchanged. (This conclusion does not hold near equilibrium.)

c. The rate of attack is decreased irreversibly by interruption of attack.

d. The film is composed of two layers whose thickness ratio remains constant during attack but varies (the thick layer increases) when the metal is completely consumed.

Most of these observations are incompatible with a model based on control by transport of reactants through the sulfide film (Wagner model), and it is concluded that a surface reaction is essentially rate-determining.

Experimental methods are described as follows: *a,* for rate determinations with a quartz spring balance; *b,* for control of the composition of hydrogen-hydrogen sulfide and helium-hydrogen sulfide mixtures by thermal-conductivity measurements; and *c,* for structural, magnetic, and chemical analysis of films.

It was shown that the kinetics of the iron-hydrogen sulfide reaction are at least partly—if not totally—controlled by some surface reaction. This conclusion is based mainly on the observation that the rate of attack (not near equilibrium) depends on the partial pressure of hydrogen sulfide and not on the partial pressure of hydrogen. (The latter gas acts merely as a diluent.) Less direct evidence is the decrease in rate resulting from crystal growth in experiments in which attack is interrupted at regular intervals. Further work is now in progress, particularly on the attack of specimens with sulfur vapor (parabolic law) followed by exposure to hydrogen sulfide (linear law), and vice versa.

("Mechanism of The Iron-Hydrogen Sulfide Reaction at Elevated Temperature," Fritz Hügli, Technical University, Winterthur, Switzerland; Charles M. Hudgins, Jr., Continental Oil Company, Ponca City, Okla.; Paul Delahay, Louisiana State University, Baton Rouge, La.)

Pretreaters Stop H_2S Corrosion. Experience with catalytic reformers having naphtha pretreaters has borne out predictions that desulfurization of the charge to below 0.002 percent by weight of sulfur would reduce high-temperature hydrogen-hydrogen sulfide corrosion of carbon and low-chromium steels in the reforming section to a negligible level. Inadequate desulfurization, caused by pretreater operating difficulties, has, in some cases, permitted scaling in reformers. Such sulfide scale, subsequently exposed to hydrogen and low hydrogen sulfide concentrations, has been reduced to metallic iron.

Although sulfide scaling in the reforming section is being eliminated in most cases, scaling in the pretreater must also be controlled. Corrosion rates in pretreaters have been, in most instances, approximately as predicted from laboratory data. Sulfide scaling has been prevented by the use of 18-8 chrominum-nickel stainless steel and calorized coatings.

While sulfide scaling has been minimized, other problems have been encountered. The most serious problems and the control methods being used are listed as follows:

1. Corrosion and fouling by chlorides in low-temperature sections of the pretreater. Acid chloride corrosion has been controlled by injection of ammonia and inhibitors and by alloying with monel. Fouling, as a result of ammonium chloride deposits formed after hydrogenation of organic chlorine and nitrogen compounds in the naphtha, has been controlled by continuous or intermittent onstream water washing.

2. Transgranular stress-corrosion cracking of austenitic stainless steel by chlorides. This has been encountered, but is being prevented by means of washing piping and exchangers with water and dilute alkaline solutions during shutdowns.

3. Intergranular cracking of unstabilized austenitic alloy lining. This occurred in one pretreater reactor, probably as a result of polythionic acids formed by the action of wet steam on sulfide scale. This has not occurred in units where stabilized alloys are used and contact of wet steam is avoided.

4. High-temperature hydrogen attack. This has been observed on a few carbon-steel internal details in reactors, but generally hydrogen damage has been avoided through the use of chromium and molybdenum steels for exposed parts and by adequate insulation of carbon steel.

("Corrosion Experience in Catalytic Reformers With Naphtha Pretreaters," E. B. Backensto, Socony Mobil Oil Co., Inc., Paulsboro, N. J.; R. W. Manuel, Socony Mobil Oil Co., Inc., New York, N. Y.)

Lab Inhibitor Stops DEA Corrosion

Corrosion studies of alkanolamine systems revealed a peculiar type of thread-like corrosion. It is called filiform corrosion and Conoco has a new inhibitor that controls it in laboratory tests.

J. D. Sudbury, O. L. Riggs and J. F. Leterle
Continental Oil Company, Ponca City, Okla.

Inasmuch as conventional inhibitors have not adequately controlled refinery alkanolamine corrosion, a laboratory study of this system was started. It was hoped that these studies would give some clue to the failure of corrosion inhibitors in this system. These studies led to the discovery of a very peculiar type of thread-like corrosion similar to filiform corrosion under paints. Based on our laboratory studies, a partial mechanism for filiform corrosion is presented. From these corrosion-mechanism studies an inhibitor was developed to stifle filiform corrosion.

Filiform Corrosion. Visual observations were made of the nature of corrosion occurring when mild steel specimens were immersed in an unstirred, aerated, 1 percent diethanolamine (DEA), 5 percent sodium chloride brine. A record of the observations of this corrosion over a 3-day period was kept by means of a 3-min. time-lapse movie. It was noted that a highly directional type of corrosion begins at sharp edges of the 1 inch by 8 inch mild steel coupon. It grows rapidly (up to ½ inch per hour) in the form of thin, thread-like filaments, as pictured in Figure 1. The metal surface beneath the filament is severely corroded. This unique type of corrosion has been designated as filiform corrosion.

Filiform Characteristics. The filiform type of corrosion has been observed in a variety of alkanolamine systems, including the following:

- Monoethanolamine
- Diethanolamine
- Methyldiethanolamine
- Dimethylethanolamine
- Diethylethanolamine
- Diethylhexylethanolamine

Alkanolamines which did not cause filiform include:

- Triethanolamine
- *n*Butyl diethanolamine
- Mono*iso*propanolamine
- Tri*iso*propanolamine
- Dibutyl*iso*propanolamine

Other amines such as morpholines, ethyleneamines (piperazines), and imidazolines do not cause filiform.

The nature of the filament can best be understood by examining the diagram in Figure 2. The filament itself may be divided into two major portions: the head and the tail. The head, or growing portion of the filament, is covered by a light blue-green product of corrosion. This is quickly oxidized to the orange-colored stable product which makes up the bulk of the filament (B). This product is covered with a thin greenish-black layer (A). The exact chemical composition and structure are not known but the product of corrosion is an iron-amine complex. The filaments are some 2 mm to 3 mm in width and grow at rates of up to ½ inch per hour.

Below the filament, the metal has been corroded away. The filament itself is hollow throughout its entire length. This hollow tube is filled with electrolyte which has a pH of less than 4.0, whereas the bulk solution has a pH of approximately 12. This low pH fluid is undoubtedly the anolyte for an electrochemical cell. The pH of 1.0 molar iron chloride is 2.6. The cell action is apparently sustained by the flow of electrolyte entering the tube at the tip of the tail and flowing through the tube to the head. This is in contrast to the filiform under paints where no hollow tube is reported and corrodents are believed to feed through the filament walls.

Some of the interesting factors affecting the rate of growth of the filament can be listed.

1. The filaments usually start growing

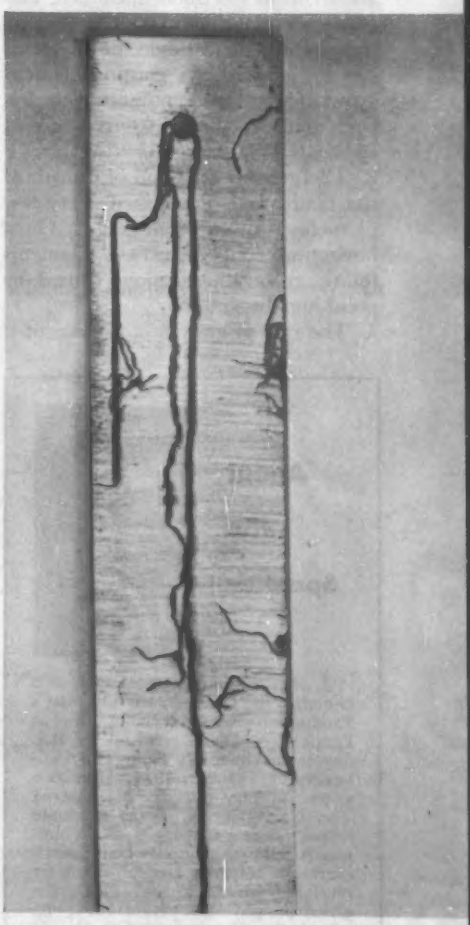


FIGURE 1—Filiform corrosion filaments start at the edge of the coupon and grow rapidly.

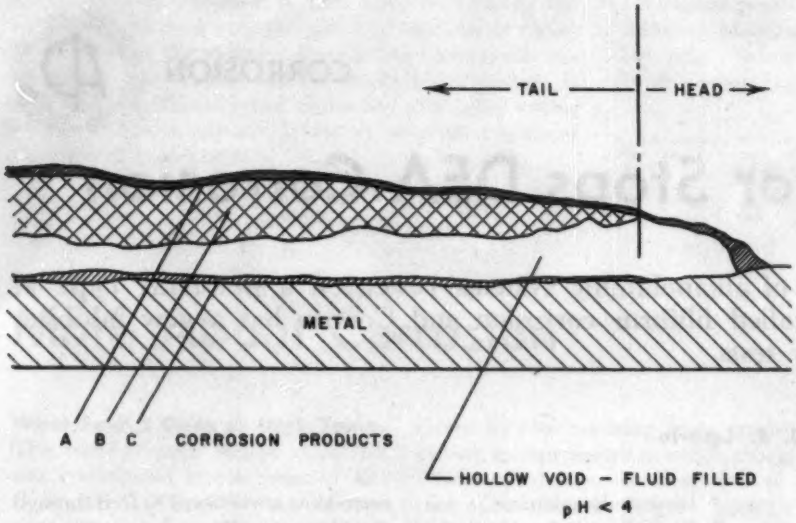


FIGURE 2—A cross-sectional diagram shows that corrosion occurs beneath the filament, which is composed of the corrosion product.

at sharp edges of the coupons. These spots are presumed to be anodic. By making a portion of the coupon the anode of an electrochemical cell, filaments are readily initiated. By making the coupon the cathode, no filaments can be induced. An existing filament grows toward any point which has been made anodic by external current application.

2. The general direction of growth of the filaments is downward. Very few filaments grow against gravity. On a horizontal coupon surface, filaments follow gross imperfections caused by polishing the coupon.

3. The rate of growth of a filament is increased several fold by cutting off part of the tail. This is believed to enlarge the hole through which the electrolyte enters the filament. On the other hand, if the tip of the tail is sealed off, the cell is immediately stifled. This seems adequate proof of the role of the hollow tube in the corrosion process.

4. The filaments never cross each other.

5. The type of mild steel or its surface preparation has no great effect.

6. Filiform corrosion occurs in both sodium chloride and sodium sulfate brines.

7. Growth is stifled by the removal of oxygen from the system.

Corrosion-Inhibitor Tests. Several known corrosion inhibitors were added to the laboratory filiform-producing DEA and monoethanolamine (MEA) systems. None of these inhibitors were effective in preventing the initiation and growth of filiform. Numerous organic materials were screened in an attempt to prevent filiform. The only type of material shown to be effective was a condensation product of polyethyleneamines and unsaturated alcohols. The general formula of these materials may be written:

$$R\,N\,\underset{H}{\overset{H}{C}}\!-\!C\equiv C\!-\!\underset{H}{\overset{H}{C}}\!-\!OH \qquad (1)$$

where R N represents the polyamine (such as tetraethylenepentamine).

The corrosion rate of the dynamic system was 96 mils per year. The surface attack resulted in small pits over the coupon. The reaction product described above (designated as T-52) gave almost complete inhibition with a 0.8-mpy corrosion rate. No surface attack was detected. These results show that T-52 controls filiform and pitting corrosion in laboratory DEA systems. Based on these encouraging results, plans were made to evaluate this inhibitor in refinery gas-sweetening units. It should be remembered that the laboratory tests were all run in the liquid phase. There is no certainty that the inhibitor will reduce the very serious corrosion often found in the vapor phase of the reactivator column.

Field History. Corrosion-inhibitor studies are being made in two of Continental Oil Company's Girbitol units.

The T-52 corrosion inhibitor is being used in the Ponca City unit. One quart a day is added slugwise into the reactivator-tower reflux stream to maintain a concentration of at least 200 ppm. The effectiveness of the inhibitor will be judged by actual equipment inspection and metal-loss measurements. This unit has now been in operation for eight months without failure.

At the Billings plant, the inhibitor is added continuously to the reactivator overhead line by means of a proportioning pump. The dosage rate is 1 quart per day. The effectiveness of the inhibitor will be determined by means of onstream corrosion-test coupons located in the liquid and vapor areas in the bottom of the reactivator tower. Duplicate coupons have been run for seven days each, to determine corrosion rates in untreated systems. The results of these tests are summarized in Table 1. The initial data after treatment with an inhibitor show a reduction in corrosion rate in the liquid phase and no reduction in the vapor phase.

TABLE 1—Coupon Data for the Billings, Mont., Girbitol Unit

Chemical Treatment	Time-Exposure Interval	Corrosion Rates of Exposed Coupons (Mils Per Year)	
		Liquid	Vapor
None	11-18-57 to 1-21-58	7.8	39.7
T-52*	1-21-58 to 1-28-58	5.9	33.9
T-52*	1-28-58 to 2- 4-58	4.0	35.6

* Reaction-product designation.

Original presentation was before the American Petroleum Institute, Division of Refining, Los Angeles, May 12, 1958, under the title "Corrosion Studies in Alkanolamine Systems."

About the Speaker

J. D. Sudbury, senior research chemist in Continental Oil Co.'s Production Research laboratory at Ponca City, Okla., received his B.S. degree in chemistry from The University of Texas in 1944. After two years military service he entered The University of Texas graduate school and received a Navy research fellowship in the University's corrosion research laboratory. After receiving his M.A. and Ph.D. degrees in physical chemistry, he joined the Continental Oil Co. in 1949.

Piping Design Stops Pulsating Flow

Reciprocating compressor piping requires special design considerations. Analog computers can be used to size the pipe and predict performance.

Ralph James
Humble Oil & Refining Company
Baytown, Texas

THE DESIGN of reciprocating compressor piping can be resolved into two catergories: (1) measures to prevent excessive mechanical vibration of the piping and (2) selection of the piping system which will provide the maximum compressor efficiency. These two categories are interrelated. For example, it may be necessary to add flow resistance at certain points to reduce pressure pulsations so that piping vibration can be minimized. The efficiency may be reduced by this step but vibration that could lead to fatigue failure is prevented.

Disturbing Forces. Both periodic machine forces and gas pulsations may provide the alternating forces which can excite mechanical vibration of piping. Machine exciting frequencies that usually must be guarded against include one half the rpm, the rpm, and multiples of the rpm up to five times the rpm. The base or fundamental pressure and flow pulsation frequency from one double-acting cylinder is twice the rpm. If more than one cylinder is discharging into the system, the pulse frequency is a function of the crank angles. Twice the fundamental pulse frequency is called the second harmonic, three times the fundamental frequency is the third harmonic, etc. The pulsations from a compressor are propagated through the piping by wave action at the speed of sound in the gas (neglecting the fluid velocity which may add or subtract velocity). The wave length of the gas pulsations is equal to the velocity of sound divided by the frequency of pulsation.

Gas pulsations (which may be considered as periodic variations in pressure or flow superimposed on steady pressure or flow) behave in the same fashion as sound waves, even though the pressure variations in sound waves are very minute. In other words, the wave theory which is used to predict acoustic phenomena such as resonance and wave addition and reflection may be applied to compressor piping design. Pulsations from a compressor may contain all the harmonics of the fundamental pulse frequency.

However, the intensity of the components decreases rapidly as the frequency increases. If the acoustic character of the piping components are such that wave reinforcement from reflections (acoustic resonance) of a certain frequency component is obtained, the resonant frequency will be amplified to produce combined pulsations of much greater intensity.

Allowable Vibration. There is always some mechanical vibration in any piping attached to a reciprocating compressor. If the vibration is perceptible and of pronounced amplitude, the piping stress and fatigue life should be calculated to determine if corrective measures should be taken. Usually, if the vibration frequency can be counted by eye there is not much likelihood of piping failure. High frequency vibrations are of greater significance—especially if the amplitude at the antinode (loop) of vibration can be visually observed. In

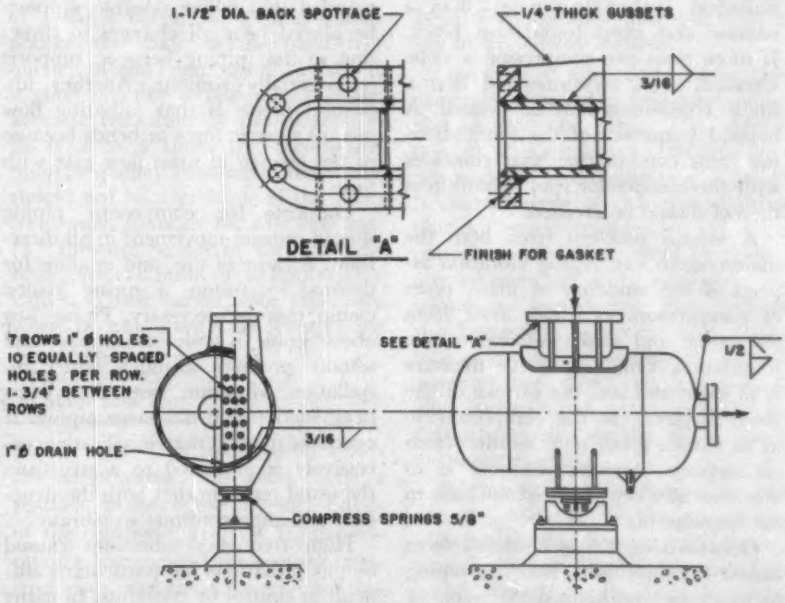


FIGURE 1—Surge bottles should be supported on springs.

one case, a ¾-inch schedule 80 instrument connection pipe attached to a 600 rpm hydrogen compressor failed in approximately three weeks.

The pipe that failed was in three planes anchored only at the ends. A similar connection on an identical spare compressor was found to be vibrating with all frequency components that were multiples of 600 cycles per minute up to 18,000 cycles per minute. Calculated stresses in this pipe based on measured amplitudes indicated a fatigue life almost exactly as occurred (considering stress intensification factors). This problem was solved by replacing part of the pipe with flexible hose. Observed fatigue life in large piping, (3 inches and over) has been much longer, usually a number of years. Since failure occurred, indications are that stress concentrations or vibration magnitude may have been underestimated.

In many cases, the alternating stresses in a vibrating pipe are not considered to be serious, but additional restraints are provided because the vibration looks bad and is a source of concern to the operators.

Foundations. A well designed foundation[1] is essential if the major portion of mechanical vibration so often present in large compressor plants is to be avoided. It is not the intent here to go into foundation design; however, a few observations may be of interest. First, a wide foundation mat of proper design provides a better installation (vibration wise) than a narrow and deep foundation block. If more than one compressor is to be installed, it is recommended that a single continuous mat be poured. A natural frequency of the foundation-soil mass combination that coincides with the compressor rpm or multiples thereof should be avoided.

A serious problem from both the maintenance and piping vibration aspects is the tendency of many types of compressors to break loose from the grout and shake relative to the foundation. One preventive measure is to slope and seal the surface of the grout adjacent to the compressor so as to reduce grout deterioration from oil seepage. Another measure is to mechanically key the machine base to the foundation.

Occasionally, it may be desirable to isolate a compressor from the piping to minimize mechanical vibration of the piping. The size and critical service of most process compressors prevent the use of most of the conventional flexible joints.

One way to provide flexible piping connections to medium size process machines handling fluids of suitable composition and temperature would be to use ball joints that employ thick contained synthetic rubber gaskets. No relative motion between the gasket and joint surfaces would be required for the moderate movements encountered. Instead, movement would occur by shear in the rubber gasket. An almost unlimited cyclic life of the joints could be obtained in this manner. This method was proposed to isolate a gas-conservation compressor which was rocking its entire foundation block.

Supports. Supports for piping attached to compressors should be so spaced that the natural frequency of the piping between supports does not coincide with significant disturbing frequencies discussed previously. Natural frequencies of straight lengths of piping with various end conditions can be easily computed.[2,3] Even though such a pipe has an infinite number of degrees of freedom, all frequencies involved are identical. On the other hand, it is difficult to calculate the spring factor for bends in one plane and three-plane sections between anchors. A number of resonant frequencies, depending on direction of vibration, can occur in these cases. For this reason, it is recommended that where possible supports be placed near all changes in direction so that piping between supports is essentially straight. Another important factor is that pulsating flow sets up a cyclic force at bends because of the change in mass flow rate with time.

Supports for compressor piping should restrain movement in all directions. Because of this, and to allow for thermal expansion, a spring loaded clamp may be necessary. Piping just above grade is easier to support and usually provides a much better installation, vibration wise, than overhead suction and discharge piping. If overhead piping that is vibrating excessively is anchored to a structure, the usual result in that both the structure and pipe continue to vibrate.

High frequency vibrations caused by gas pulsations are particularly difficult to control by restraints. In many cases, the gas pulsations must be reduced before a restraint becomes effective.

To avoid cylinder alignment problems, the piping forces on the cylinder nozzles should be quite low. The flexibility of a seemingly massive cast iron structure is quite surprising. It is recommended that there be no rigid piping between the cylinder and foundation, i.e., the lower bottle should be supported on springs, (multi-spring type with damper) and the layout of piping should provide some inherent flexibility in other directions. The use of cast iron base ells and cast iron transition pieces between cylinders and bottles should be avoided. (See Figure 1 for suggested connecting nozzle details).

In a number of vibration studies, it has been determined that the compressor cylinder will vibrate relative to the crankshaft centerline. This movement occurs because of the periodic elongation and contraction of the distance piece and other compressor parts. Ordinarily this small movement is of no concern, but may need to be considered if extremely rigid piping is involved.

Design of Surge Bottles

When Required? All large compressors require surge bottles immediately adjacent the suction and discharge flanges of each cylinder. Sufficient capacity for small compressors may be obtained by increasing the size of the suction and discharge lines to one or more pipe sizes larger than the compressor inlet or outlet. Surge bottles serve two purposes. (1) A surge capacity will help reduce the transmission of compressor pulsations into the piping system and (2) efficiency of the compressor will be improved by adequate surge capacity. A surge bottle on the suction side will decrease pressure drop at the valves on the suction stroke, thereby preventing cylinder "starvation." It has been reported that cylinder capacity has been reduced by as much as 25 percent by operating without a suction surge chamber.[4] A discharge surge chamber will tend to prevent greater than average momentary pressure in the discharge valve chamber. Momentary pressures can result in severe overloads and may also reduce capacity. Acoustic pulsations also play a part in determining the effect of surge capacity—as will be discussed later.

Techniques used to size surge bot-

tles vary widely. A survey of a number of compressor installations placed in service over the last 15-20 years (excluding certain recent installations) revealed no correlation between surge capacity and compressor or fluid characteristics. Bottle capacities ranged from 0 to 15 or more times the piston displacement volume. Some installations have proven satisfactory. Other installations have a history of piping failure and maintenance problems. While attempting to correct some of the more troublesome vibration problems, it became obvious that piping design, including acoustic phenomena, was an important factor. The need for a logical and consistent design technique was evident. Sample surge bottle calculations in the appendix illustrate the different methods used by various designers as recorded in the literature or learned first hand.

Semi-Empirical Methods. Semi-empirical methods are usually based on experience and/or fluid flow analysis. Usually, however, the derivation is not supplied. These methods are easy to apply and may be satisfactory for cost estimating and certain actual installations. The disadvantage of this rule-of-thumb approach is that acoustic resonance factors are ignored. On occasion, this has resulted in unsatisfactory installations. In one case involving three identical compressors, piping vibration was reduced by replacing the acoustically resonant interstage bottle and piping with a new design. It is believed that fluid pulsations occurring in the original installation contributed to the excessive maintenance costs experienced.

Surge Tank Approach. On pages 333 to 335 of Reference 5 is an idealized derivation of the amount of pulse smoothing to be expected from a volume capacity (energy storage) acting together with a moderate pressure drop (resistance) of the piping system. The effectiveness of the surge tank is expressed as the attenuation factor

$$\text{factor} = \text{A.F.} = \frac{\text{Inflow Variation Relative to Mean Flow Rate}}{\text{Outflow Variation Relative to Mean Flow Rate}}$$

Thus, an attenuation factor of 20 indicates the amplitude of pulsations has been reduced to 5 percent of the original value.

The advantage of this method is that it is based on a logical analysis which gives some insight into the expected pulsation attenuation. The problem of selecting a satisfactory attenuation factor and pressure drop is difficult. The usual procedure is to make the bottle as large as practical so that the highest possible A.F. is obtained. Method 5C. will give an erroneous answer if the size arrived at is resonant to the compressor exciting frequency. This brings up the next topic—acoustic resonance.

Acoustic Resonance. Consider a capacity volume with a neck such as would correspond to a surge bottle and the nozzle connecting the bottle to the compressor cylinder. This acoustic element is known as a Helmholtz resonator. It is supposed that the air in the neck vibrates as a solid mass while the air in the chamber acts as a spring as it is alternately compressed and rarified. The acoustic resonate frequency of this device can be calculated by methods detailed in the appendix.

The acoustic frequency of sections of piping can be determined by the familiar "organ pipe" formulas. Acoustic frequencies of various combined systems are discussed in Reference 5. The polar-diagram methods of determining natural frequencies discussed by Warming[6] may be easier to apply in many cases.

In general, the acoustic frequency of a surge bottle and piping should not be the same as the pulse frequency of the compressor. In fact, it is good practice to design so that the acoustic frequency of the surge bottle is 3 to 4 times the compressor pulse frequency (computed frequency should not be a multiple of the pulse frequency. Reasons for this rule are: (1) Pressure surges in the bottle at resonance can build up to appreciable values. These surges can, especially when in phase with the compressor pulses, "starve" or overload the cylinder as previously discussed. Such a reaction between the pressure pulses of the comprssor and the fundamental or a harmonic of the acoustic pressure wave may cause, severe vibration from varying power requirements (as waves change phase), overloading of the driver, poor compressor capacity, or valve breakage.[14] (2) The bottle will no longer act to attenuate the compressor pulses but may increase the transmission of pulses into the piping system. (Of interest is that Rayleigh (Sound, 2, p 42) has proved mathematically that the mean pressure inside a resonator is greater than that in the surrounding medium.)

Plane Wave Theory Filters. This method of attack in designing pulsation attenuation filters is well described in References 8 and 9. A brief explanation is as follows. When longitudinal waves (such as a sound wave or pressure wave) traveling through a pipe arrive at a discontinuity (surge chamber, etc.) where the acoustical impedance (Ratio of pressure to the product of linear velocity and the cross sectional area) is either much higher or much lower than the characteristic impedance of the pipe, only a small fraction of the acoustical energy can flow through the discontinuity. The rest of the energy goes into a reflected wave that originates at the discontinuity and travels back toward the source. Thus, the transmission of energy can be reduced by inserting suitable discontinuities in the pipe, even though these discontinuities may not absorb any of the energy directly.

One type of filter designed by this principle is called a low-pass pulsation damper or filter. This device consists of a combination of two bottles and an interconnecting pipe. It is characteristic of this arrangement that all wave frequencies up to a point known as the cut-off frequency are transmitted with negligible attenuation through the filter. Above this frequency, up to the next transmission band (1st pass band), all frequencies are effectively attenuated. The higher band passes need to be determined but usually these bands are quite narrow.

By increasing the length or decreasing the size of the connecting pipe, the volume needed for the surge bottles can be reduced. However, the length of pipe is a factor in determining the high-pass bands.[10] The de-

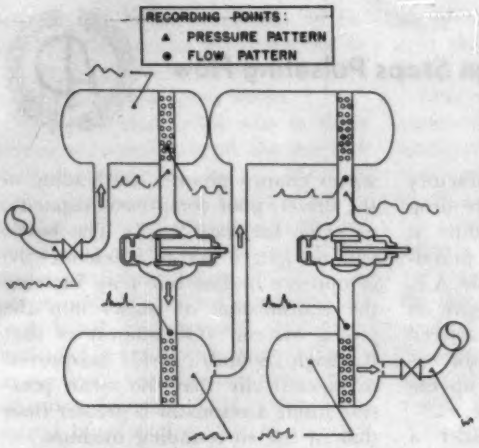


FIGURE 2—Analog computer used to simulate this system.

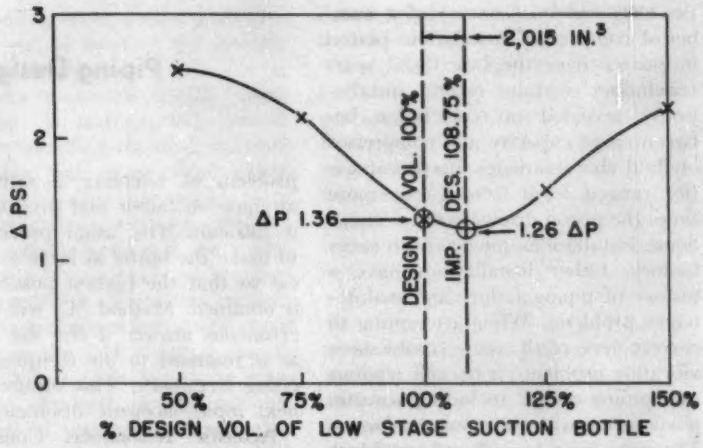


FIGURE 3—A minimum pulsation occurs in the low-stage suction bottle when the compressor is operated at 300 rpm.

sign should be such that the first and second band-pass frequencies do not correspond to harmonics of the compressor frequency. The resonant frequency of the piping components adjacent to the compressor should not coincide with the compressor base frequency or the first and second harmonics.

Space requirements may limit the application of this type filter. Also, the cost of two separate bottles may be greater than the cost of a suitable single bottle even though internal pulse attenuating devices are required in the single bottle.

As can be seen by comparing the surge bottle requirements determined by methods detailed in the appendix, the designer is faced with a selection of method, allowable pressure drop, and surge amplitude. Based on three methods from different sources the proper size of the capacity bottle for the case stated is approximately five times the swept volume of the cylinder. The same result could be obtained by the use of another method if an allowable pressure fluctuation of 7.65 percent is selected. Also involved, is the economic problem of reducing first cost while considering future maintenance and operating efficiency.

Baffles. A baffle is a plate or tube containing multiple holes. The baffle is arranged in the capacity chamber so that the large flow stream is divided into individual streams which flow through the baffle holes and are recombined again into a single stream. One or more baffles have been found to be quite effective in reducing pulses without significant pressure loss. For the size dampeners used on compressors, the diameter of holes in the tubular type baffle is usually ¾ inch to 1 inch. Enough holes are provided so that the combined flow area of the baffle is greater than the flow area of the single stream of the inlet or outlet nozzle.

The author knows of no mathematical study of the action of a baffle. Possibly the action might be as follows. First, the baffle orifices act preferentially on the high velocity pulsating flow component, i.e., the resistance to flow through an orifice is proportional to the square of the velocity. Therefore, the resistance to steady flow is nil while the resistance to the high velocity components of pulsating flow is appreciable. Another important factor may be the reflection of the waves from the orifices. Also, the multiple transmitted waves may recombine to produce a much smoother wave pattern because of phase differences. A typical baffle installation is detailed in Figure 1.

Orifices. In a number of cases, the installation of an orifice upstream of a vibrating piping system has greatly reduced the amplitude of vibration. Only a nominal pressure drop across the orifice is usually sufficient. Several successful orifice installations were designed to produce a pressure drop across flange taps of 1 percent of the average line pressure. Steady flow conditions were assumed.

Pulsation Control. (a) Arrive at a tentative capacity volume for each side of each cylinder by one of the semi-empirical methods discussed previously.

(b) Check the acoustic resonant frequency of the various piping system components singly and in combination to determine if acoustic resonant frequencies coincide with the pulse frequencies of the compressor. If necessary make changes to the piping components. In general, pipe sizes should be somewhat larger than a size established by pressure drop calculations which assume steady flow.

(c) Design a cylindrical baffle for each surge bottle.

(d) Size an orifice for the last surge bottle outlet flange for a pressure drop across flange taps of 1 percent of the average discharge line pressure.

Figure 1 is a drawing of a typical surge bottle of a type now being tested in several installations. Adequate reinforcing of nozzles and bracing of small piping connections is extremely important. Supports and bracing for small piping should be carefully detailed. Often this problem is neglected, resulting in vibration and possible breakage.

Admittedly, some of these recommendations are based on experience and rule-of-thumb techniques. For this reason, efforts are being made to increase the knowledge of acoustic phenomena. The only known practical way to completely analyze a compressor installation is by means of an analog computer, which is recommended for all critical compressor installations.

Analog Computer Tests. It became evident during the investigation of pulsating flow that the available mathematical methods left much to be desired since the complete system should be considered as a whole. The

great many factors involved made mathematical analysis prohibitive. Even if one case could be worked mathematically, a change in one component would require that the entire problem be reworked.

The use of an electrical analog is based on the fact that mechanical, electrical, and acoustical phenomena are analogous and can be expressed in the same mathematical language.[7,12,13,14] For example, the circuit of an acoustic analog would behave electrically precisely as the compressor and associated piping behave acoustically. Electrical voltage corresponds to gas pressure, electrical current corresponds to gas flow, and electrical frequency corresponds to acoustic frequency. Measurement of the voltage and current patterns at certain points of the analog circuit indicate compressor performance with various piping systems, compressor loads, compressor ratios, and speeds.

On investigation, it was soon learned that only a very large analog computer could handle a compressor problem, and only a few such installations are available. The problem was discussed with Walter Brunner, an Applications Engineer for the Princeton Computation Center, which is an analog and digital computer center maintained by Electronic Associates, Incorporated. After analyzing the problem, Brunner and his associates arrived at an analog circuit which was different from some reported in the literature in that the elements of the circuit were *active*. An *active* component analog consists primarily of high gain amplifiers which can by various external electrical hookups be made to differentiate, integrate, add, multiply, divide, provide various voltage patterns with time. etc. A *passive* element analog consists primarily of resistances, condensers, and inductances. The advantage of the *'active'* element computer is that system nonlinearities are easily handled.

Nonlinear characteristics must be included in a system analysis in order to optimize volumetric efficiency. For example, compressor phenomena and compressor valve characteristics are nonlinear. The analog developed produces a very accurate simulation of the pressure-volume relationship within the cylinder. This relationship was derived from a consideration of the energy balance including gas flow. The actual piston displacement with time was used in the simulation. Heat loss effects including transfer of heat through the piston rings, piston ring friction, etc. can be simulated if desired. The valve analogy used in the test case assumed the flow across the valve to be proportional to the square root of the pressure drop, but ignored valve *inductance*. Since then the inductance term has been included.[16]

To evaluate the analog circuit, it was decided to simulate an actual compressor system which had been designed by conventional methods. The computer results would then be checked against the actual performance.

Figure 2 is a schematic of the system tested. Pressure and flow patterns were recorded on strip charts with 200 mm of the chart coresponding to one second of real time. X-Y plotters were connected to draw P-V diagrams of both the head end and crank end of each cylinder.

At first the entire system was being simulated. However, there was a tendency for the interstage pressure to drift upward. Because of time limitations, it was then decided to run each stage separately. Changes to any part of the simulated system was easily done by adjusting potentiometers or other computer components. However, the optimization of the system by varying all components until best results were obtained from the compressor could not be completed in the time available. Items that can be determined from the test data include:

Size of Surge Bottles. If the peak-to-peak pressure variations in the low-stage suction bottle are plotted against the simulated volume, the curve in Figure 3 is obtained. From this curve it appears that a volume of approximately 20,750 cubic inches will result in a minimum pressure pulsation in the low-stage suction surge bottle when the compressor rpm is 300. Either increasing or decreasing the volume would result in greater pressure surges. However, the pressure pulsation level is not the only factor to be considered in piping design. A maximum compressor efficiency is the real goal.

Pulsation Frequency. A Fourier analysis can be made of the pressure or flow pattern strip charts by means of a mechanical analyzer. This analysis will show the intensity and phase angle of the various frequency components making up the complex wave pattern. A number of the wave patterns recorded during this test have been analyzed which show that the intensity of some of the harmonics of the compressor pulse frequency are quite high.

Varying Suction Pressure. Since three 600 rpm compressors are connected to the same headers as the compressor under test, it was decided to make two simulated runs on the analog with simulated varying suction pressures. Runs were made with the pressure in the suction header varying sinusoidally ± 10 percent at 600 and 1200 cycles per minute. During the 600 cycle-per-minute disturbance the pressure variations in the line to the compressor increased 250 percent as compared to the pressure variations with constant header pressure. A beat frequency was also discernable. The pressure pulses in the suction surge bottle increased 100 percent; however, the volumetric efficiency of the compressor did not seem to be much affected. Varying the suction pressure at 1200 cycles per minute did not have nearly so great affect as the 600 cycle per minute variation.

Valve Chamber Volume. It was

TABLE 1—Comparison of Three Pressure-Volume Diagrams

DIAGRAM	Work Per Cycle, In. Lbs.	Indicated Horsepower At 300 RPM*	Delivered Flow Per Cycle In. 3 at Suction Conditions	In.-Lbs. of Indicated Work Per Cubic In. of Gas Delivered
1. Ideal	107,000	81.2	4140	25.8
2. Computer with piping not connected**	117,000	88.5	4220	27.8
3. Computer with piping connected	131,400	99.5	4740	27.8

* Compressor diagrams are for 300 rpm.
** Constant pressure supplied at valves. The valve loss can be estimated by comparing this diagram with the ideal diagram.

found that the compressor-valve-chamber volume had a pronounced effect on the pressure and flow patterns. This factor is not considered in other techniques of compressor piping design.

Compressor Efficiency. Table 1 is a comparison of three pressure-volume diagrams of the low-stage head end.

The last column is a measure of the compressor efficiency—the lower the number—the greater the efficiency. Note that though the indicated horsepower increases when the piping is connected, a compensating increase in flow is achieved. However, at 320 rpm, it requires 30.2 inch-pounds of indicated work per cubic inch of fluid delivered at suction conditions. By comparisons such as this, it is believed that the computer can indicate the conditions that will provide the maximum compressor efficiency.

In this connection, it would help to have an electronic circuit to measure the average flow. This can easily be done by adding some integrators to the circuit. The strip/chart flow pulses are too small for accurate planimeter readings.

Data from the analog test are now being checked by comparison with actual compressor installations.

A beat-frequency pressure pattern was made recording from one suction line of a multiple compressor installation similar to, but not the same as, the one simulated on the analog. An alternate reinforcing and cancelling action between pressure pulses from adjacent compressors was observed and was predicted by the analog analysis. Such a phenomena has long been suspected to be the cause of the periodic variations in the intensity of mechanical vibration at certain compressor installations. At some of these installations, pulsation snubbers have greatly reduced the pressure variations. A quartz crystal transducer together with an amplifier—calibrator that operates by an electrostatic principle was used to obtain the actual pressure patterns. The amplifier—calibrator output was connected to an oscilloscope and a polaroid camera was used to photograph the pressure versus time patterns displayed on the oscilloscope. It is obvious from this study that the analog computer circuit can very closely simulate the complex acoustic interactions that occur in a compressor piping system.

The author is convinced that an analog computer is the most practical way to study flow and pressure variations in a complex piping system. In addition, the analog computer provides a means whereby the total system can be analyzed to determine optimum piping design and operating conditions.

Originally presented before the API Division of Refining, Los Angeles, May 13, 1958.

About the Speaker

Ralph James, Jr., is a supervising engineer in the Engineering division of the Design department at Humble Oil and Refining Co.'s Baytown refinery. He has a B.S. degree in mechanical engineering from the University of Texas and an M.S. degree in mechanical engineering from the University of Houston. James is a member of ASME, the American Welding Society, the American Society for Metals, and the Texas Society for Professional Engineers.

LITERATURE CITED

[1] Veltrop, Jan A., Vibrations of Machinery Foundations, Doctoral Thesis submitted at the Massachusetts Institute of Technology, June, 1953.

[2] Macduff, J. N. and Felgar, R. P., Vibration Design Charts, ASME Paper No. 56-A-75.

[3] Den Hartog, J. P., Mechanical Vibrations, Third Edition, McGraw-Hill Book Company, Inc., New York, N. Y., 1947, pp 457-480.

[4] Cumiskey, J. E., et al., "Reciprocating Compressor Special Report," *Petroleum Refiner*, 35, No. 11, 120-150 (Nov. 1956).

[5] M. W. Kellogg Company, Design of Piping Systems, Second Edition, John Wiley & Sons, Inc., 1956.

[6] Warming, Troels, "Polar Diagram for Tuning of Exhaust Pipes," *Trans. ASME*, 68, 31-34 (Jan. 1946).

[7] Murphy, E. F., Natural Frequencies of Piping Systems As Determined By Electrical Analogy, Doctoral Thesis submitted at Illinois Institute of Technology, June, 1948.

[8] Davis, D. D., et al., Theoretical and Measured Attenuation of Mufflers At Room Temperature Without Flow, With Comments on Engine Exhaust Muffler Design, NACA Technical Note 2893, February, 1953.

[9] Harris, C. M., (Editor), Handbook of Noise Control, McGraw-Hill Book Company, Inc., New York, N. Y., 1957.

[10] Taylor, C. N., "How to Stop Troublesome Pulsation Without Excess Pressure Drop," *The Oil & Gas Journal*, 110-112 (Mar. 8, 1954) 113-117 (Mar. 15, 1954).

[11] Baird, R. C., and Bechtold, I. L., "The Dynamics of Pulsative Flow Through Sharp-Edged Orifices," *Trans. ASME*, 74, 1381-1387 (Nov. 1952).

[12] Domewood, G., "Electrical Analog Helps Solves Design Problems," *The Oil & Gas Journal*, 98-101, Aug. 6, 1956.

[13] Henderson, E. N., "Gas Pulsations-The Problem, Southern Gas Association's Approach and Results," ASME Paper No. 57-OGP-9.

[14] Chilton, E. G. and Handley, L. R., "Pulsations in Gas Compressor Systems," *Trans. ASME*, 74, 931-943, (1952).

[15] Des Jardines, P. R., et al., "Handling Compressible Fluids," *Chemical Engineering*, 178-238, June 1956.

[16] Brunner, Walter, Electronic Associates, Inc., Private Correspondence.

More About Piping

Cr-Mo Alloys at High Temperatures: The influence of prolonged service at elevated temperatures and pressures on the high-temperature strength of Cr-Mo heat resistant alloy tubing has been evaluated. Creep-rupture tests were conducted with longitudinal coupon specimens machined from the walls of four 5 Cr-½ Mo alloy furnace tubes retired from service after times ranging from 44,000 to 115,000 hours. These data indicated no deterioration in creep-rupture strength of the base metal resulted from prolonged exposure to pressure at metal temperatures of 1,100 to 1,160 F. Similarly, room temperature tensile and impact properties were not changed significantly.

Tubular creep-rupture test results on 5 Cr-½ Mo furnace tubing after 118,000 hours of high-temperature service agreed well with the coupon data and showed no significant decrease in high-temperature strength. Creep-rupture tests on both longitudinal and transverse strip specimens cut from a 9 Cr-1 Mo alloy furnace tube stressed for a design life of 15,000 hours and removed after 12,750 hours of high-temperature service, indicated no appreciable deterioration in creep-rupture strength.

The creep-rupture test data from this test program on Cr-Mo alloy furnace tubing retired from service have indicated no decrease in creep-rupture strength despite prolonged exposure at elevated temperatures and pressures.

("The Influence of Prolonged Service at Elevated Temperatures and Pressures on the High-Temperature Strength of Chromium-Molybdenum Alloy Tubing," John F. Ewing, The Babcock and Wilcox Co., Beaver Falls, Penn.)

How Do Mixtures Affect Knock Ratings?

Studies reveal how hydrocarbon types influence the knocking tendencies of blends. These data help formulate a model to predict the interaction among gasoline components.

Eric J. Y. Scott
Socony Mobil Oil Company, Inc.
Paulsboro, N. J.

THE HIGH compression ratios in modern cars insure that the intrinsic power of the fuel is used as economically as possible; however, the accompanying knock restriction has now become a limiting factor in choosing fuel blends.

API Research Project 45 has made substantial contributions toward determining the knock ratings of pure hydrocarbons in the gasoline boiling range.[1] However, detailed information of this nature does not give unequivocal values for the knock ratings of hydrocarbon blends. Thus the octane number of a blend cannot always be computed by adding the octane numbers of the blend components in proportion to their relative concentrations.

Ethyl Corporation[2] made the first

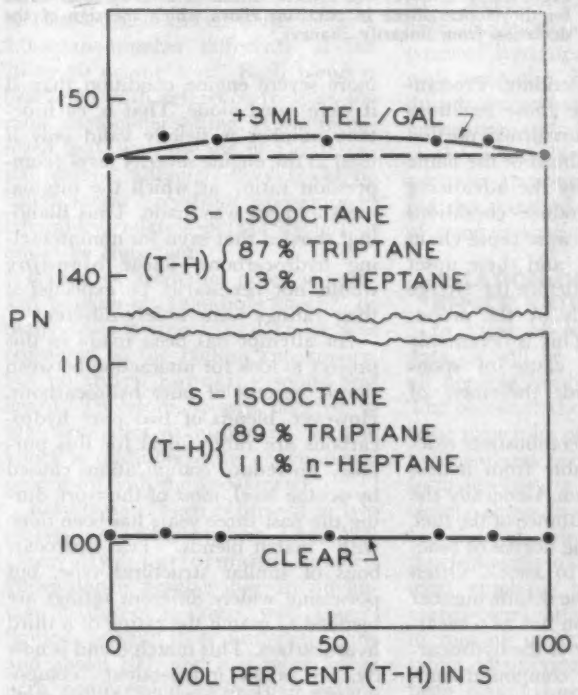


FIGURE 1—Paraffins blend linearly with other paraffins when the engine severity conditions are constant.

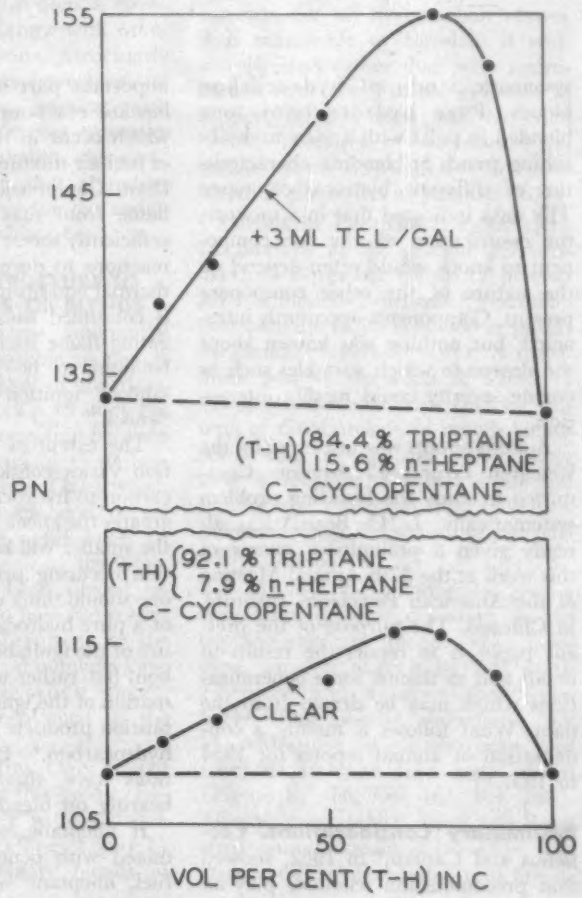
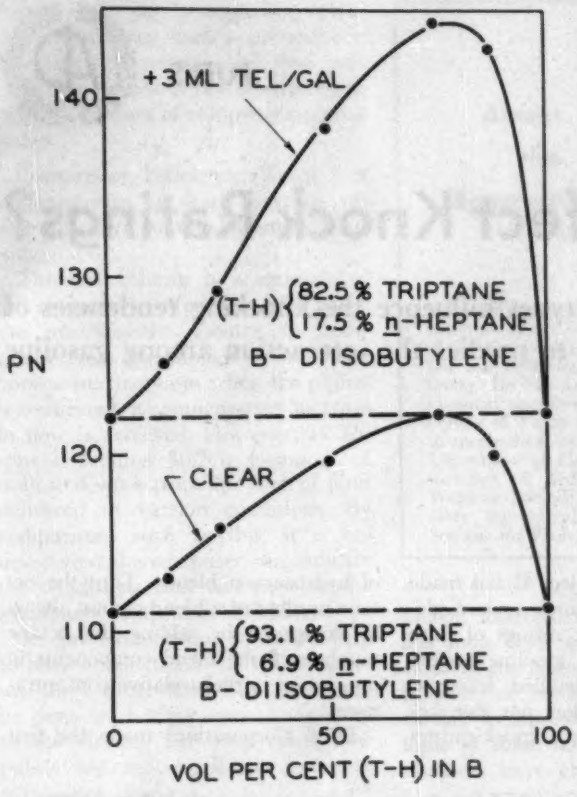


FIGURE 2 (Right)—Naphthenes give positive deviations which are greater as the performance-number level increases.



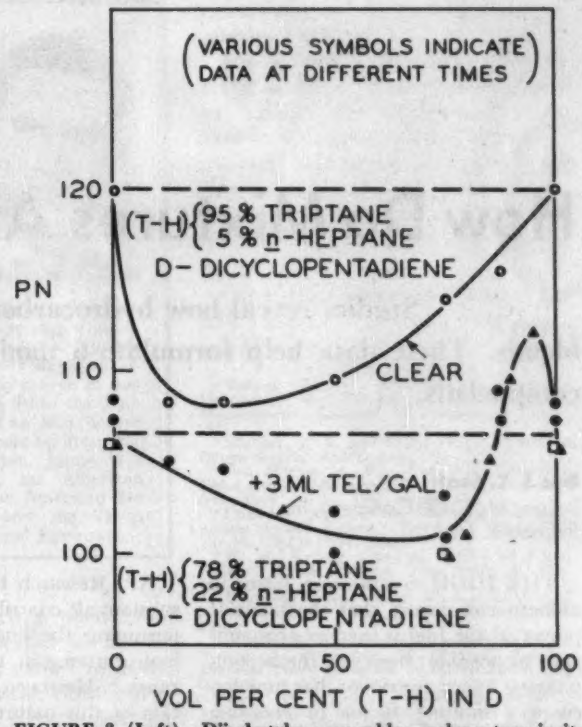


FIGURE 3 (Left)—Diisobutylene resembles cyclopentane in its behavior in paraffin blends.

FIGURE 4 (Above)—A critical threshold severity level exists for dicyclopentadiene in paraffins above which the sign of the deviation from linearity changes.

systematic study of hydrocarbon blends. Pure hydrocarbons were blended in pairs with a view to establishing trends in blending characteristics of different hydrocarbon types. The data indicated that in a mixture, the contribution of any one component to knock would often depend on the nature of the other component present. Components apparently interacted, but nothing was known about the degree to which variables such as engine severity could modify interaction.

A study group was instituted by the Research Project 45 Advisory Committee to study the blending problem systematically. L. C. Beard[3] has already given a preliminary review of this work at the 37th Annual Meeting of the American Petroleum Institute, in Chicago. The purpose of the present paper is to report the results in detail and to discuss some generalizations which may be drawn from the data. What follows is mainly a condensation of annual reports for 1954 to 1957.[4,5,6]

Preliminary Considerations. Cornelius and Caplan,[7] in 1952, showed that precombustion reactions play an important part in blending. Precombustion reactions are those reactions which occur in the unburned portion of fuel-air mixtures ahead of the flame front. Compression by the advancing flame front may produce conditions sufficiently severe to cause rapid chain reactions to develop, and these upset thermal equilibrium before the charge is consumed smoothly by the propagating flame itself. This is commonly believed to be the cause of spontaneous ignition and, therefore, of "knock."

The extent of precombustion reaction varies considerably from hydrocarbon to hydrocarbon. Generally the greater the knock resistance of the fuel, the smaller will be the degree of reaction occuring prior to knock. Often one should think of the octane number of a pure hydrocarbon not as a measure of the ignitability of the hydrocarbon, but rather as a compound summation of the ignitabilities of precombustion products as well as the parent hydrocarbon.[8] Precombustion reactions have, therefore, an important bearing on blending.

If *n*heptane, a low-octane fuel, is mixed with benezene, a high-octane fuel, *n*heptane will be exposed to a more severe engine condition than if it were rated alone. That is, each octane number is strictly valid only if used at the engine severity level (compression ratio) at which the original measurement was made. Thus Blanding[9] showed that even for noninteracting hydrocarbons, linear blending would not necessarily be expected if their ratings were widely different.

An attempt has been made in this project to look for interaction between simple systems of pure hydrocarbons. However, blends of two pure hydrocarbons are rarely ideal for this purpose. To reduce complications caused by octane level, most of the work during the past three years has been done with "match blends." Two hydrocarbons of similar structural type, but possessing widely different ratings are blended to match the rating of a third hydrocarbon. This match blend is now treated as an independent "component" in a binary system. An example is shown in Figure 1. In this case a triptane-*n*heptane blend constitutes the match blend; *iso*octane is the third hydrocarbon.

Objectives. A high degree of precision was required for this program.

Special precautions were taken to insure: (1) a high degree of purity of the hydrocarbons; (2) minimum degradation or peroxidation on storage; (3) accurate blending; and (4) accurate knock rating.

F. H. Blanding prepared an operation manual which was used to insure that a uniform procedure was followed in each knock-rating laboratory. Moreover, the supervisors of the knock-testing laboratories convened at a general meeting to discuss and modify special techniques described in the manual.

ASTM Research and Motor Methods were used throughout the program.[10] Conventional knock ratings have a repeatability of approximately ±0.5 octane as standard error. The precision of the Research and Motor Methods was improved by the addition of some restrictive test conditions. Thus an entire series of samples for one group of blends was rated in the same engine, by the same operator, and on the same day.

When deviations from linearity were small ($\leq$ 0.4 octane number), a *differential method* was used. The knockmeter was adjusted to a spread of 15 to 20 knockmeter divisions for a 2.0-octane-number difference at the 70 to 90 octane level. Each blend is bracketed with reference fuels at the same micrometer setting. It was recognized that, with the use of a differential method, although *absolute* octane values might vary from laboratory to laboratory, *relative octane deviations* might be consistent.

Rating of aromatics posed a problem because of "inaudible knock." In many cases pronounced knock was registered on the Phillips knockmeter, but no sharp knocking sound was heard. Therefore, it was decided to rate aromatics at constant audible knock in addition to the conventional procedure with the knockmeter.

Results have been expressed in two units: octane number and A-N (army-navy) performance number. Performance number has an advantage in that it is linear, with knock-limited power; it is uniform below and above 100; and it is more linear with compression ratio than octane number is.[11] Inasmuch as Blanding's results indicated that the compression-ratio scale is fairly linear, performance number has been the favored unit in the present paper. However, this choice does not affect the conclusions drawn because these conclusions were based on match-blend data.

Two formulas[12] have been used to correlate octane number (ON) with performance number (PN): below 100, $PN = \frac{2,800}{128 - ON}$; above 100, $ON = 100 + \frac{PN - 100}{3}$. Conventional ASTM ratings and differential ratings were averaged as follows: below 100, octane numbers were averaged; above 100, performance numbers were averaged. To conserve space, only the performance numbers of check points and other auxiliary points have been recorded.

The standard errors involved in rating triptane-*n*heptane match blends in different laboratories are 1.2 for clear blends and 2.0 for leaded blends. Above 100 PN, the former value increases slightly to 1.4. Laboratory-to-laboratory variations are thus relatively small for paraffin blends. However, variations are larger with other types of hydrocarbons, particularly with aromatics. Errors have been reduced somewhat by working with never more than 75 percent aromatics in the blend. Nevertheless, the main problem at present is that of reducing the standard error for the rating of pure aromatic hydrocarbons.

RELATION OF STRUCTURE TO KNOCK RATINGS OF BLENDS

In view of the large amount of data, it will be impossible to discuss all possible implications of the data. The object of the work is to study the basic principles of interaction between hydrocarbons producing deviations from linearity in blends. Cases which clearly show that interaction occurs are thus of primary significance. In the following discussion, therefore, most emphasis has been placed on match-blend data. To help the reader in making quick references to the tables, identifying blend numbers have been parenthesized when specific blends have been mentioned in the text.

Paraffins in Paraffins. Only limited data are available in this group. *Iso*octane blends linearly with a match blend of triptane-*n*heptane (Figure 1) (38). In general, binary blends of paraffins are approximately linear on an octane-number basis but give negative deviations with the use of performance numbers (e.g., 2). However, the *iso*octane-triptane blend exhibits a positive deviation with the use of either scale. Nevertheless, in the light of evidence available, it appears likely that paraffins blend linearly with other paraffins when the engine severity conditions are constant.

Naphthenes in Paraffins. Cyclopentane in a triptane-*n*heptane match blend exhibits a striking maximum positive deviation of 8.0 PN at 30 percent by volume of cyclopentane (Figure 2) (39). Cyclohexane, methylcyclohexane, and ethylcyclo-pentane give much smaller maximum positive deviations with paraffin substrates (40, 52, 53). In general, greater deviations are observed at high performance-number levels than at low levels. Inasmuch as the effect appears to be common for all hydrocarbon classes, it is reasonable to correlate it with severity level rather than with hydrocarbon structure. Further evidence in support of this view will be cited herein. Mixtures of naphthenes resemble pure naphthenes in their blending properties in paraffns (64).

Olefins in Paraffins. Di*iso*butylene (a mixture of 85 percent 2,4,4-trimethyl-1-pentene and 15 percent 2,4,4-trimethyl-2-pentene) resembles cyclopentane in its behavior in paraffin blends (Figure 3) (41). A maximum positive deviation of 11 to 12 PN is observed at 25 percent by volume of di*iso*butylene in match blends comprising triptane and either *n*heptane or *iso*octane. The magnitude and sign of the deviation are, therefore, independent of the nature of the paraffin components.

2-Methyl-2-pentene also gives a very large positive deviation in the triptane-*n*heptane blend (42); however, paraffin match blends with 2-heptene and *a*-pinene show relatively small positive deviations (43, 54). Mixtures of di*iso*butylene and 1-hexene behave like pure olefins (Figure 6) (66, 156, 161, 164, 168). All the cases which have just been cited parenthetically illustrate that larger positive deviations from linear-

ity occur at higher performance-number levels.

Three paraffins have been tested in diisobutylene-1-hexane match blends (58, 59, 60). In each case, a maximum positive deviation of approximately 5 PN was observed. Thus, in all cases where paraffins and olefins have been matched, positive deviations have been observed.

Diolefins in Paraffins. Dicyclopentadiene in paraffin match blends exhibits a marked negative deviation (Figure 4) (44, 50). Also, the blend of dicyclopentadiene and triptane itself is highly negative in character. However, blends with *iso*octane and *n*heptane show positive deviations. These facts suggest that a critical threshold severity level exists for dicyclopentadiene-paraffin blends above which the sign of the deviation from linearity changes. 2-Methyl-1,3-butadiene exhibits a positive deviation in

TABLE 1—Research Ratings Unleaded

Identification Number[a]	Component A	Component B		OCTANE AND PERFORMANCE NUMBERS							
				Volume Percent B in Blend							
				0	12.5	25	50	75	87.5	100
HYDROCARBON PAIRED WITH A MATCH-BLEND										
(1) "B" is Paraffin										
38-2-9	Isooctane	89% Triptane	ON	100.1	100.1	100.0	100.1	100.1	100.1	100.0
		11% n-Heptane	PN	100.2	100.3	100.1	100.2	100.3	100.2	100.0
39-1-6	Cyclopentane	92.1% Triptane	ON	102.6	103.2	103.6	104.3	105.2	104.4	102.6
		7.9% n-Heptane	PN	107.8	109.6	110.8	113.0	115.6	113.3	107.8
			%			65				
			PN[b]			115.6				
40-2-10	Cyclohexane	72.5% Triptane	ON	84.0	85.0	85.2	86.0	85.3	85.4	84.8
		27.5% n-Heptane	PN	63.7	65.1	65.5	66.8	65.6	65.8	64.9
			%			37.5				
			PN[b]			66.23				
41-1-4	Diisobutylene	93.1% Triptane	ON	103.7	104.3	105.3	106.5	107.4	106.6	103.7
		6.9% n-Heptane	PN	111.1	113.0	115.8	119.6	122.2	119.8	111.1
42-2-10	2-Methyl-2-pentene	85% Triptane	ON	96.2	97.0	98.0	100	101.0	99.6	96.1
		15% n-Heptane	PN	88.0	90.4	93.5	99.9	102.9	98.7	88.0
			%				62.5			
			PN[b]				101.37			
43-1-3	2-Heptene	67.6% Triptane	ON	76.9	78.0	78.7	80.0	80.2	78.7	77.1
		32.4% n-Heptane	PN	54.8	56.0	56.8	58.3	58.6	56.8	55.0
44-1-8	Dicyclopentadiene	94.7% Triptane	ON	106.7	102.8	102.8	103.2	104.7	105.2	106.7
		5.3% n-Heptane	PN	120.2	108.4	108.4	109.5	114.0	115.6	120.2
			%	75	87.5	91.0	94.0	97.0	.....	100
			PN[b]	112.2	114.6	116.3	117.2	117.7	.....	119.2
45-2-8	2-Methyl-1,3-butadiene	87.7% Triptane	ON[i]	97.7	98.0	98.6	99.3	101.1	101.9	98.0
		12.3% n-Heptane	PN[i]	92.4	93.3	95.3	97.5	103.2	105.7	93.3
46-3-6	Orthoxylene	94.5% Triptane	ON	106.7	103.5	102.0	102.2	103.4	104.6	106.2
		5.5% n-Heptane	PN[d]	120.0	110.5	106.0	106.6	110.2	113.7	118.5
47-1-1	Ethylbenzene	96.6% Triptane	ON	108.5[e]	109.5[e]	109.7[e]	110.0[e]	110.3[e]	109.7[e]	108.5[e]
		3.4% n-Heptane	PN	125.6[e]	128.6[e]	129.1[e]	130.1[e]	130.9[e]	129.0[e]	125.6[e]
			PN[b]	127.7[e]	128.7[e]	129.0[e]	130.1[e]	130.8[e]	130.1[e]	.....
47-1-2	Ethylbenzene	95% Triptane	ON	105.2	107.8	107.8	108.2	108.6	107.6	105.0
		5% n-Heptane	PN	115.6	123.5	123.5	124.7	125.7	122.8	115.1
			PN[b]	.....	.....	123.3	125.4	125.7	122.8	.....
48-3-3	Amylbenzene	75.5% Triptane	ON	87.6	87.0	86.3	85.9	86.2	86.5	87.3
		24.5% n-Heptane	PN	69.3	68.3	67.2	66.5	67.0	67.5	68.8
49-1-4	Diisobutylene	27% Triptane	ON	103.3	103.7	104.7	106.3	107.4	107.2	103.3
		73% Isooctane	PN	109.9	111.1	114.0	118.8	122.2	121.6	109.9
50-1-8	Dicyclopentadiene	60% Triptane	ON	106.7	106.2	106.0	103.6	102.9	103.3	106.7
		40% Isooctane	PN	120.2	118.5	118.0	110.8	108.7	109.9	120.2
			PN[b]	.....	.....	115.8	.....	.....	.....	.....
51-1-1	Ethylbenzene	63.1% Triptane	ON	108.7[e]	109.2[e]	109.4[e]	110.1[e]	110.6[e]	110.3[e]	109.0[e]
		36.9% Isooctane	PN	126.0[e]	127.6[e]	128.2[e]	130.4[e]	131.8[e]	130.9[e]	127.1[e]
			PN[b]	.....	126.4[e]	128.2[e]	130.4[e]	131.8[e]	130.2[e]	126.1[e]
			PN[b]	.....	.....	.....	.....	.....	.....	127.0[e]
51-1-2	Ethylbenzene	4.5% Triptane	ON	105.4	107.8	107.8	108.3	110.4	108.4	105.2
		55.5% Isooctane	PN	116.1	123.5	123.5	124.9	131.3	125.1	115.6
			PN[b]	.....	.....	123.7	124.9	131.3	125.1	.....
52-1-7	Methylcyclohexane	74.7% Isooctane	ON[d]	74.7	75.2	75.6	76.2	76.2	75.9	74.8
		25.3% n-Heptane	PN	52.5	53.0	53.4	54.1	54.1	53.8	52.6
53-1-5	Ethylcyclopentane	61.8% Isooctane	ON[d]	62.5	64.9	62.7	63.3	64.2	63.1	62.6
		38.2% n-Heptane	PN	42.8	44.4	42.9	43.3	43.9	43.2	42.8
			PN[b]	42.0	42.9	42.7	42.8	43.5	42.8	42.2
54-1-7	α-Pinene	83.1% Isooctane	ON[d]	83.2	85.0	85.9	87.8	88.5	87.3	83.1
		16.9% n-Heptane	PN	62.5	65.1	66.6	69.7	70.9	68.8	62.4
(2) "B" is Naphthene										
55-2-3	Cyclohexane	23% Cyclopentane	ON	84.8	85.1	84.9	84.8	84.5	84.0[i]	84.7
		77% Methylcyclohexane	PN	64.8	65.3	65.0	64.8	64.4	63.6[i]	64.7
(3) "B" is Olefin										
56-1-5	Cyclopentane	90% Diisobutylene	ON	101.6	101.6	101.4	101.3	101.2	101.4	101.6
		10% 2-Heptene	PN[d]	104.9	104.9	104.3	103.8	103.6	104.2	104.9
57-2-6	2-Methyl-2-pentene	54% Diisobutylene	ON[d]	96.8	97.0	97.1	97.2	97.0	97.1	96.7
		46% 2-Heptene	PN	89.7	90.3	90.6	90.9	90.3	90.6	89.5
58-3-2	2,3-Dimethylbutane	98% Diisobutylene	ON	104.2	105.4	105.6	105.2	104.7	104.3	104.0
		2% 1-Hexene	PN	112.5	116.3	116.8	115.6	114.1	112.8	111.9
59-3-1	2-Methylbutane	41.5% Diisobutylene	ON[e]	93.7	94.7	94.3	95.9	94.3	95.3	93.5
		58.5% 1-Hexene	PN	81.6	84.1	83.1	87.2	83.1	85.6	81.2
60-3-2	2,2-Dimethylbutane	36% Diisobutylene	ON	91.9	93.2	94.0	94.3	93.3	92.4	91.7
		64% 1-Hexene	PN	77.6	80.5	82.4	83.1	80.7	78.7	77.1
(4) "B" Contains Aromatic										
61-2-2	Isooctane	80.5% Ethylbenzene	ON	100.0	100.3	100.3	100.4	100.0	100.0	100.0
		19.5% n-Heptane	PN	100.0	100.8	100.8	101.2	100.0	100.0	100.0
			PN[i]	100.0[e]	98.9[e]	98.2[e]	96.9[e]	94.9[e]	94.0[e]	93.3[e]
62-2-2	Cyclopentane	76% Ethylbenzene	ON	102.1	102.0	101.8	101.9	101.7	101.8	102.3
63-2-1	Diisobutylene	24% Methylcyclohexane	PN	106.4	106.1	105.4	105.7	105.0	105.4	106.8
		79.2% Ethylbenzene	ON	103.1	103.1	103.0	102.8	102.9	103.3	103.1
		20.8% 2-Heptene	PN	109.3	109.3	108.9	108.3	108.7	109.2	109.3

How Do Mixtures Affect Knock Ratings?

its match blend (45). However, mixtures of the two diolefins in triptane-*n*heptane match blends also possess a threshold value in the region of 100 PN to 106 PN (68, 69). It should be noted that both these compounds are difficult to rate. The carburetor must be heated for dicyclopentadiene and cooled for 2-methyl-1,3-butadiene. Nevertheless, the consistency of the results indicates that the severity threshold effect is real.

Aromatics in Paraffins. The results in this group are complicated by the difficulty encountered in rating pure aromatics. Tentatively, it appears that aromatics do not form a consistent class with respect to their behavior in paraffin substrates. Only ethylbenzene shows a positive deviation (47, 51). Orthoxylene, paraxylene, and amylbenzene all exhibit varying degrees of negative deviation (46, 48).

To obtain more reliable values for aromatics, some ratings have been made with ethylbenzene-paraffin mixtures in paraffin match blends. These blends are essentially linear (61, 70).

Additivity. Both positive and negative deviations have been observed in the work which has been described herein. Two tests for additivity have been made. At low concentrations the effects of di*iso*butylene and cyclopentane in a paraffin substrate were quantitatively additive (Figure 5) (65). However, the effects of di*iso*butylene and dicyclopentadiene in a paraffin substrate were only qualitatively additive (67).

Naphthenes in Naphthenes. Cyclohexane blends linearly with a cyclopentane-methylcyclohexane match blend (55). It is reasonable to infer that, given constant engine conditions, naphthenes will, in general, mutually blend in a linear manner.

Olefins in Naphthenes. 2-Heptene blended with methylcyclohexane gives a slight positive deviation. Also, di*iso*butylene-1-hexene mixtures blend linearly with a naphthene match blend having a value of 58.3 PN. However, corresponding blends above 100 PN exhibit slight negative deviations (56, 71).

Diolefins in Naphthenes. A mixture of dicyclopentadiene-2-methyl-1,3-butadiene blended with a cyclopentane-methylclohexane at the 102-PN level showed a distinct negative deviation (72).

Aromatics in Naphthenes. Unlike naphthene blends in paraffins, naphthene blends in aromatic-paraffin match blends give slight negative deviations (73). This is somewhat surprising because olefins, which usually parallel naphthenes in blending behavior, give positive deviations with aromatic paraffins (see following section). Aromatic-naphthene match blends in naphthenes appear to be also slightly negative in character (62).

Olefins in Olefins. 2-Methyl-2-pentene blends almost linearly with a di*iso*butylene-2-heptene match blend (57).

Diolefins in Olefins. Dicyclopentadiene and di*iso*butylene exhibit a definite negative deviation when mutually blended. Similarly, a mixture of dicyclopentadiene and 2-methyl-1,3-

TABLE 1—Continued

Identification Number[a]	Component A	Component B		OCTANE AND PERFORMANCE NUMBERS Volume Percent B in Blend						
				0	12.5	25	50	75	87.5	100
TWO MATCH-BLENDS										
(1) "B" is Paraffin										
64-3-9	83.3% Cyclopentane	90.44% Triptane	ON	102.9	103.9	104.5	105.4	105.4	104.6	102.3
	16.7% Methylcyclohexane	9.56% n-Heptane	PN	108.8	111.8	113.5	116.2	116.1	113.8	106.8
65-2-4	50% Diisobutylene	92.1% Triptane	ON	103.1	103.7	104.1	105.9	106.7	106.2	103.1
	50% Cyclopentane	7.9% n-Heptane	PN	109.3	111.1	112.2	117.7	120.2	118.7	109.3
66-3-9	75.2% Diisobutylene	90.44% Triptane	ON	101.6	102.7	104.0	105.6	106.6	105.5	101.0
	24.8% 1-Hexene	9.56% n-Heptane	PN	104.7	108.1	112.1	116.9	119.7	116.4	103.1
67-2-4	50% Diisobutylene	92.4% Triptane	ON	103.3	103.3	103.0	102.9	103.1	104.0	103.3
	50% Dicyclopentadiene	7.6% n-Heptane	PN	109.9	109.9	109.0	108.7	109.3	111.9	109.9
68-2-4	50% Dicyclopentadiene	91.9% Triptane	ON	102.8	102.6	102.6	102.1	102.1	103.3	102.8
	50% 2-Methyl-1,3-butadiene	8.1% n-Heptane	PN	108.4	107.7	107.7	106.3	106.3	109.9	108.4
69-3-9	37% Dicyclopentadiene	90.44% Triptane	ON	99.8	99.8	99.8	99.9	100.8	101.1	100.3
	63% 2-Methyl-1,3-butadiene	9.56% n-Heptane	PN	99.3	99.3	99.3	99.7	102.3	103.3	100.9
70-3-9	81.75% Ethylbenzene	90.44% Triptane	ON	101.7	101.5	101.6	101.6	101.6	101.5	101.5
	18.25% n-Heptane	9.56% n-Heptane	PN	105.2	104.6	104.7	104.7	104.7	104.6	104.5
(2) "B" is Naphthene										
71-3-9	75.2% Diisobutylene	83.3% Cyclopentane	ON	102.0	101.7	101.7	101.9	102.1	102.1	102.2
	24.8% 1-Hexene	16.7% Methylcyclohexane	PN	105.9	105.1	105.1	105.8	106.4	106.3	106.7
72-3-9	37% Dicyclopentadiene	83.3% Cyclopentane	ON	97.9	97.7	96.5	95.2	95.9	98.1	101.5
	63% 2-Methyl-1,3-butadiene	16.7% Methylcyclohexane	PN	93.0	92.4	88.9	85.4	87.3	93.7	104.4
73-3-9	81.75% Ethylbenzene	83.3% Cyclopentane	ON	100.4	100.2	99.9	100.0	100.7	101.5	102.6
	18.25% n-Heptane	16.7% Methylcyclohexane	PN	101.2	100.6	99.6	100.0	102.2	104.7	108.0
(3) "B" is Olefin										
74-3-9	37% Dicyclopentadiene	75.2% Diisobutylene	ON	100.5	100.2	99.9	99.5	99.6	99.8	100.5
	63% 2-Methyl-1,3-butadiene	24.8% 1-Hexene	PN	101.5	100.5	99.5	98.3	98.6	99.3	101.6
75-3-9	81.75% Ethylbenzene	75.2% Diisobutylene	ON	101.3	101.9	102.2	102.2	102.2	101.9	101.5
	18.25% n-Heptane	24.8% 1-Hexene	PN	103.9	105.6	106.7	106.6	106.6	105.7	104.5
(4) "B" is Diolefin										
76-3-9	81.75% Ethylbenzene	37% Dicyclopentadiene	ON	100.2	100.1	100.0	99.5	99.6	99.9	100.2
	18.25% n-Heptane	63% 2-Methyl-1,3-butadiene	PN	100.6	100.2	99.9	98.3	98.7	99.5	100.7

butadiene in a matched olefin blend exhibits a negative deviation (74).

Aromatics in Olefins. In all cases of aromatic-paraffin blends in matched olefin blends, a positive deviation was observed (75), although the magnitude was very small at low levels. This behavior is dissimilar to the behavior of naphthenes in similar blends. However, aromatic-olefin blends in olefin exhibited a slightly negative deviation (63).

Aromatics in Diolefins. A marked negative deviation was observed when an aromatic-paraffin blend was mixed with a matched diolefin blend (76).

Conclusions. 1. Interactions are best studied by noting the deviations from linearity which occur with hydrocarbons in match blends. In this way, severity-level effects are minimized.

2. Deviations from linearity are common.

3. Hydrocarbons belonging to the

TABLE 2—Research Ratings Containing 3 Ml TEL Per Gal

Identification Number[a]	Component A	Component B		OCTANE AND PERFORMANCE NUMBERS Volume Percent B in Blend						
				0	12.5	25	50	75	87.5	100
HYDROCARBON PAIRED WITH A MATCH-BLEND										
(1) "B" is Paraffin										
88-2-9	Isooctane	87.0% Triptane	ON	115.6	116.0	115.9	115.9	115.9	115.9	115.6
		13.0% n-Heptane	PN	146.7	147.9	147.6	147.6	147.7	147.7	146.8
89-1-6	Cyclopentane	84.4% Triptane	ON	111.2	113.0	113.7	116.5	118.3	117.4	111.0
		15.6% n-Heptane	PN	133.7	138.9	141.1	149.4	155.0	152.2	132.9
90-2-10	Cyclohexane	70.5% Triptane	ON	98.0	98.0	97.2	97.2	97.5	98.0	98.0
		29.5% n-Heptane	PN	93.3	93.3	90.9	90.9	91.8	93.3	93.3
91-1-4	Diisobutylene	82.5% Triptane	ON	107.4	108.4	109.7	112.8	114.8	114.3	107.4
		17.5% n-Heptane	PN	122.0	125.1	129.2	138.4	144.4	142.8	122.2
92-2-10	2-Methyl-2-pentene	73.4% Triptane	ON	99.4	100.8	100.6	102.9	103.2	102.4	99.9
		26.6% n-Heptane	PN	98.0	102.5	101.9	108.6	109.6	107.2	99.7
			%				67.5			
			PN[b]				109.1			
93-1-3	2-Heptene	60.3% Triptane	ON	90.4	91.3	92.0	92.3	91.9	91.1	90.3
		39.7% n-Heptane	PN	74.5	76.3	77.8	78.4	77.6	75.9	74.3
94-1-8	Dicyclopentadiene	78.0% Triptane	ON	102.5	101.7	101.6	100.8	100.3	102.5	102.5
		22.0% n-Heptane	PN	107.4	105.0	104.7	102.4	100.8	107.4	107.4
			PN[b]	108.4	.....	.....	100.0	103.2	109.0	108.4
			%	75.0	87.5	90.0	92.5	93.75	95.0	100
			PN[b]	100.0	107.4	107.4	108.1	110.5	109.3	106.7
95-2-5	Dicyclopentadiene	90% Triptane[k]	%	.....	.....	50	90	94	97	100
		10% n-Heptane[k]	PN	.....	.....	100.0	120.8	129.7	131.6	152.5
			PN[b]	.....	.....	.....	.....	131.6	134.1	.....
96-2-5	Dicyclopentadiene	95% Triptane[k]	%	.....	.....	50	90	94	97	100
		5% n-Heptane[k]	PN	.....	.....	101.5	124.4	131.6	134.1	154
			PN[b]	.....	.....	.....	.....	134.1	137.2	.....
97-3-8	Orthoxylene	82.0% Triptane	ON	105.0	103.4	102.6	102.0	102.9	103.1	105.0
		18.0% n-Heptane	PN	115.0	110.2	107.8	106.0	108.7	109.3	115.0
			PN[b]	.....	.....	.....	105.7	.....	.....	115.6
98-1-1	Ethylbenzene	87.1% Triptane	ON	114.3	114.7	116.8	120.7	121.0	118.7	114.5
		12.9% n-Heptane	PN	143.0	144.1	150.5	162.0	163.0	156.2	143.5
			PN[b]	.....	.....	.....	.....	.....	.....	143.6
98-1-2	Ethylbenzene	80.9% Triptane	ON	104.0	105.4	105.8	105.8	109.2	106.0	103.7
		19.1% n-Heptane	PN	111.9	116.3	117.4	117.4	127.6	117.9	111.1
			PN[b]	.....	.....	117.4	117.4	127.6	117.9	.....
99-3-4	Amylbenzene	73.5% Triptane	ON	99.0	98.7	97.8	96.7	95.9	95.4	98.9
		26.5% n-Heptane	PN	96.6	95.6	92.7	89.5	87.3	85.9	96.2
100-1-7	Methylcyclohexane	66.0% Isooctane	ON[d]	89.1	89.2	89.2	89.2	89.2	89.2	88.9
		34.0% n-Heptane	PN	72.2	72.2	72.2	72.2	72.2	72.2	71.6
101-1-5	Ethylcyclopentane	57.0% Isooctane	ON[d]	82.7	82.9	83.0	83.0	83.4	83.5	83.2
		43.0% n-Heptane	PN	61.8	62.1	62.2	62.2	62.8	62.9	62.4
102-1-3	2-Heptene	70.7% Isooctane	ON	90.5	91.4	91.9	92.5	91.8	91.7	90.4
		29.3 n-Heptane	PN	74.7	76.5	77.6	78.9	77.4	77.2	74.5
103-1-7	α-Pinene	64.0% Isooctane	ON	87.3	87.9	88.6	90.4	90.2	89.0	87.3
		36.0% n-Heptane	PN	68.8	69.9	71.1	74.5	74.1	71.8	68.8
			PN[b]	.....	.....	.....	.....	.....	.....	68.7
104-2-7	Dicyclopentadiene	90.7% Isooctane	ON	103.1	101.8	101.7	101.1	101.7	100.3	102.1
		9.3% n-Heptane	PN	106.4	105.4	105.0	103.2	105.0	109.9	106.4
			%	.....	.....	.....	.....	94	97	.....
			NP[b]	.....	.....	.....	.....	116.3	111.1	.....
105-2-8	2-Methyl-1,3-butadiene	70.8% Triptane	ON	97.8	98.5	98.7	100.3	102.5	102.6	98.0
		29.2% n-Heptane	PN	92.7	95.0	95.6	100.8	107.4	107.7	93.3
(2) "B" is Naphthene										
106-2-3	Cyclohexane	25% Cyclopentane	ON	97.3	97.3	97.3	97.3	97.3	97.4	97.3
107-1-6	Dicyclopentadiene	75% Methylcyclohexane	PN	91.2	91.2	91.2	91.2	91.2	91.5	91.2
		43% Cyclepentane	ON	101.8	101.3	99.9	97.5	97.4	99.0	101.8
		57% Methylcyclohexane	PN	105.4	104.0	99.6	91.8	91.5	96.6	105.5
			%				63			
			PN[b]				88.6			
(3) "B" is Olefin										
108-2-6	2-Methyl-2-pentene	40% Diisobutylene	ON[d]	99.0	99.0	99.0	98.8	99.0	98.8	98.8
		60% 2-Heptene	PN	96.6	96.6	96.6	95.9	96.6	95.9	95.9
109-1-6	Dicyclopentadiene	62.5% Diisobutylene	ON	102.0	101.3	100.8	99.4	98.9	99.5	102.0
		37.5% 2-Heptene	PN	106.1	104.0	102.4	97.9	96.2	98.2	106.1
(4) "B" contains Aromatic										
110-2-2	Isooctane + 1.0 ml TEL/gal.	86% Ethylbenzene	ON	108.6	111.0	111.4	111.0	110.0	109.3	108.7
		14% n-Heptane + 1.0 ml TEL/gal.	PN	125.7	132.9	134.3	133.1	130.0	127.9	126.2
			PN	125.7[e]	131.2[e]	132.0[e]	130.0[e]	125.7[e]	122.8[e]	123.1[e]
111-2-2	Cyclopentane	76% Ethylbenzene	ON	109.9	109.8	109.8	109.8	109.9	109.9	109.9
		24% Methylcyclohexane	PN	129.6	129.4	129.4	129.4	129.6	129.6	129.6
112-2-1	Diisobutylene	70.4% Ethylbenzene	ON	104.8	104.7	104.6	104.5	104.6	104.7	104.8
		29.6% 2-Heptene	PN	114.5	114.1	113.8	113.6	113.8	114.1	114.5

same class blend linearly. Also, blending is almost linear if an aromatic is included with one of the components.

4. Mixtures of hydrocarbons from any one class simulate the blending behavior of pure hydrocarbons belonging to the same class, the deviation from linearity is, at least qualitatively, a sum of the effects of the components taken separately.

5. When two hydrocarbons from different classes are blended in a match blend of hydrocarbons belonging to a third class, the deviation from linearity is, at least qualitatively, a sum of the effects of the components taken separately.

6. Higher positive deviations are noted at high performance-number levels than at low levels. An exception is the case of diolefin. In paraffin substrates diolefins exhibit a performance-number threshold above which deviations change sign (from positive to negative).

7. Olefins and naphthenes generally exhibit similar blending characteristics. They both give distinct positive deviations with paraffin match blends, with a maximum approximately at 50 to 75 percent paraffin. A mutual blend of olefins and naphthenes is almost linear.

8. Diolefins exhibit negative deviations with all classes; however, below 100, positive deviations are noted with paraffin blends.

9. The largest deviations occur when one of the components is a paraffin.

10. No generalization can be made concerning aromatics as a class.

Effect of Tetraethyllead. At the end of the first phase of the program, it appeared that TEL increased the positive deviation or decreased the negative deviation from linearity. This generalization was based on clear and leaded paraffin match blends with cyclopentane (Figure 2) (39, 89), di-*iso*butylene (Figure 3) (41, 91), dicyclopentadiene (Figure 4) (44, 94), and ethylbenzene (47, 98). Since then, a number of examples have been found involving various combinations of hydrocarbons in which the effect has been in the opposite direction (40, 90; 42, 92; 48, 99). Therefore, no generalization can be made at this time.

Even in cases where the TEL produces large increases in the positive deviation from linearity, the effect can be ascribed to the higher severity levels obtained by adding TEL rather than to the TEL *per se*.

A remarkable similarity may be noticed in the behavior of leaded blends compared with that of the corresponding clear blends. Thus the general conclusions described for clear blends broadly apply for leaded blends, too. Therefore, it is unnecessary to comment in as much detail as was done in the foregoing sections on clear blends. However, some notable exceptions to the generalizations should be pointed out.

One would have expected that

TABLE 2—Continued

Identification Number[a]	Component A	Component B		OCTANE AND PERFORMANCE NUMBERS Volume Percent B in Blend						
				0	12.5	25	50	75	87.5	100
TWO MATCH-BLENDS										
(1) "B" is Paraffin										
113-3-10	40.5% Cyclopentane	76.27% Triptane	ON	100.7	101.1	101.2	101.0	100.7	100.6	100.5
	59.5% Methylcyclohexane	23.73% n-Heptane	PN	102.1	103.3	103.6	103.0	102.1	101.8	101.6
114-2-4	50% Diisobutylene	83.6% Triptane	ON	108.7	110.8	111.7	114.7	116.7	115.7	108.7
	50% Cyclopentane	16.4% n-Heptane	PN	126.1	132.2	135.2	144.0	150.0	147.0	126.1
115-3-10	50.5% Diisobutylene	76.27% Triptane	ON	101.3	101.8	102.6	104.3	103.1	101.5	100.2
	49.5% 1-Hexene	23.73% n-Heptane	PN	103.9	105.4	107.6	113.1	109.3	104.5	100.6
			PN[b]	103.8	106.1	108.5	112.5	111.3	106.9	104.8
116-2-4	50% Diisobutylene	77.5% Triptane	ON	101.9	101.8	101.6	101.8	103.7	105.3	101.9
	50% Dicyclopentadiene	22.5% n-Heptane	PN	105.7	105.4	104.7	105.4	111.1	116.0	105.7
117-2-4	50% Dicyclopentadiene	75.5% Triptane	ON	100.4	100.0	99.8	100.1	101.9	103.6	100.4
	50% 2-Methyl-1,3-butadiene	24.5% n-Heptane	PN	101.2	100.0	99.3	100.4	105.7	110.8	101.2
118-3-10	84% Dicyclopentadiene	76.27% Triptane	ON	101.1	100.8	100.5	99.7	99.9	101.8	100.5
	16% 2-Methyl-1,3-butadiene	23.73% n-Heptane	PN	103.3	102.3	101.6	98.9	99.6	105.3	101.6
119-3-10	69.5% Ethylbenzene	76.27% Triptane	ON	100.9	100.7	100.6	100.4	100.3	100.2	100.2
	30.5% n-Heptane	23.73% n-Heptane	PN	102.8	102.0	101.8	101.1	100.8	100.6	100.5
(2) "B" is Naphthalene										
120-3-10	50.5% Diisobutylene	40.5% Cyclopentane	ON	101.2	101.3	101.6	101.9	102.1	102.1	101.4
	49.5% 1-Hexene	59.5% Methylcyclohexane	PN	103.6	104.0	104.8	105.7	106.2	106.3	104.3
121-3-10	84.0% Dicyclopentadiene	40.5% Cyclopentane	ON	101.4	100.5	99.5	97.0	96.6	98.2	101.2
	16.0% 2-Methyl-1,3-butadiene	59.5% Methylcyclohexane	PN	104.3	101.4	98.2	90.3	90.2	94.0	103.7
122-3-10	69.5% Ethylbenzene	40.5% Cyclopentane	ON	100.5	100.0	99.2	99.0	99.6	100.2	100.9
	30.5% n-Heptane	59.5% Methylcyclohexane	PN	101.6	100.0	97.2	96.6	98.6	100.6	102.7
(3) "B" is Olefin										
123-3-10	84.0% Dicyclopentadiene	50.5% Diisobutylene	ON	101.5	101.1	100.0	99.1	98.4	98.8	101.5
	16.0% 2-Methyl-1,3-butadiene	49.5% 1-Hexene	PN	104.4	103.2	100.0	96.9	94.6	95.9	104.4
124-3-10	69.5% Ethylbenzene	50.5% Diisobutylene	ON	100.8	101.2	101.6	102.2	101.4	101.3	101.1
	30.5% n-Heptane	49.5% 1-Hexene	PN	102.3	103.7	104.7	106.5	104.2	104.1	103.4
(4) "B" is Diolefin										
125-3-10	69.5% Ethylbenzene	84.0% Dicyclopentadiene	ON	100.5	100.3	98.8	99.3	100.3	100.7	101.1
	30.5% n-Heptane	16.0% 2-Methyl-1,3-butadiene	PN	101.6	101.0	95.9	97.6	100.9	102.2	103.4
			PN[b]	102.8	102.9	97.9	98.6	102.7	104.2	106.7

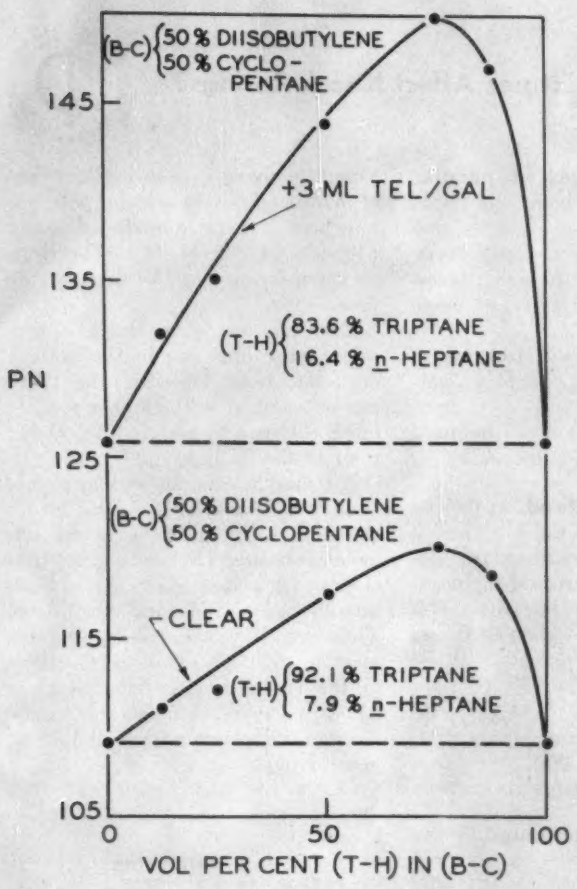


FIGURE 5—Positive and negative deviation are only qualitatively additive.

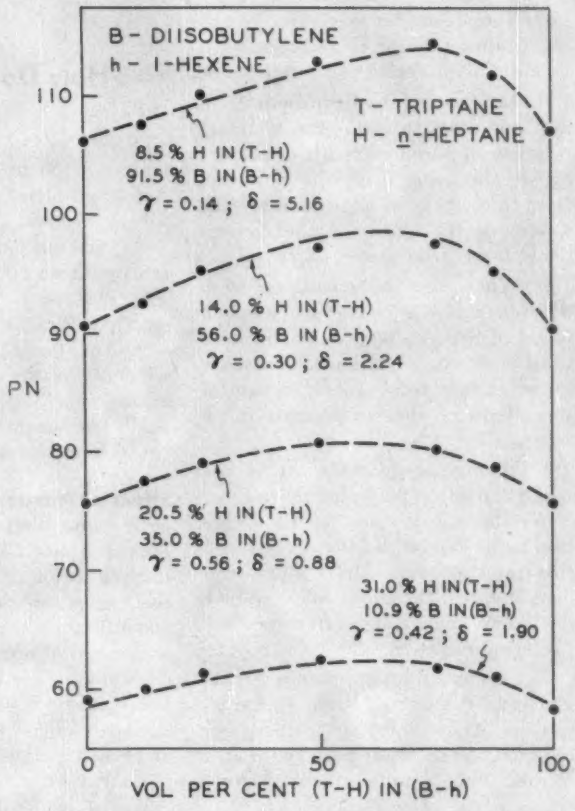


FIGURE 6—Parameters are evaluated to fit an equation to the simplest cases.

leaded *iso*octane would blend linearly with a leaded match blend of ethylbenzene and *n*heptane. In actual fact, a distinct positive deviation was noted (110).

Cyclopentane, methylcyclohexane, ethylcyclopentane, and cyclopentane-methylcyclohexane blends conform to the general rule that *higher* performance-number levels give *higher* positive deviations from linearity. Cyclohexane, is a notable exception (90). At approximately the 90-PN level, cyclohexane gives a distinct negative deviation from linearity. This would not have been predicted from the clear blend which exhibits a positive deviation (40).

Dicyclopentadiene in paraffin match blends shows a distinctly anomalous curve which has been well checked (Figure 4) (94). Unlike the corresponding clear blend with *n*heptane (44), the leaded blend not only shows a negative deviation (like the clear blend), but also has a positive maximum at 93.75 percent paraffin. A number of factors have been studied: *a*, other substrates (104, 107, 109); *b*, the concentration of *n*heptane in the blend (95, 96); *c*, the nature of the diolefin (105, 117, 118, 123); and, *d*, change from the Research to the Motor Method of rating. It was found that ethylbenzene behaved similarly; that a paraffin substrate was necessary, but the nature of the paraffin was probably not important; that the anomaly occurred with blends of dicyclopentadiene with 2-methyl-1,3-butadiene; and that the anomaly was not observed where the ratings were made by the Motor Method. The evidence pointed toward the importance of engine severity conditions. However, no anomaly occurred when N-methylaniline was used instead of TEL to attain approximately the same severity level.

Examples such as this, in which the blending curve is of a decidedly complex nature, are not easy to interpret unequivocally. However, such anomalies may present important clues concerning mechanisms. For this reason, their study is pertinent and complementary to a broader study of "normal" curves.

Effect of N-Methylaniline. Blends containing N-methylaniline have been run to attempt to differentiate between effects attributable to TEL and to severity level. These experiments have met with only partial success. In general, blends with N-methylaniline exhibited less positive interaction than the corresponding

TABLE 3—Calculation of Blending Parameters for Equation (1)

Blend Number	Percent by Volume of *n*Heptane in Triptane-*n*Heptane Match Blend	Percent by Volume Diisobutylene–1-Hexene Match Blend	Performance Number	Calculated Parameters γ	δ
156	8.5	91.5	106	0.14	5.16
161	14.0	56.0	90	0.30	2.24
164	20.5	35.0	76	0.56	0.88
168	31.0	10.9	59	0.42	1.90

clear blends. N-methylaniline (like TEL) exhibited a pro-knock effect.

Effect of Rating Method. Two generalizations can be made concerning Motor Methods ratings, with regard to the magnitude and sign of their deviations, compared with those found for corresponding Research Method ratings:

1. When a hydrocarbon blends approximately linearly with its match blend by the Research Method, blending is also linear for the corresponding blends by the Motor Method.

2. When a hydrocarbon with its match blend exhibits a deviation from linearity by the Research Method, the deviation for the corresponding blend rated by the Motor Method is more negative (Fig. 2). In one case, the change involves a reversal of sign. Amylbenzene is an exception to the foregoing rule.

Both increasing compression ratio and changing from Research to Motor Method alter the severity of engine conditions. Increasing compression ratio increases both the temperature and density of the end-gas, whereas changing from Research to Motor Method increases temperature but decreases density. Inasmuch as positive deviations increase with increasing compression ratio but decrease with the change of method, it appears that the magnitude of positive deviation is a function of the density rather than the temperature of the end-gas.

The generalizations already reached have been based on Research Method data for hydrocarbons mixed with their match blends. Inasmuch as there are insufficient data, no sound conclusion can be made on how Motor Method ratings conform to these generalizations. We can say definitely that hydrocarbons belonging to the same class blend linearly. However, the general effect of severity level is obscure because there are not enough data for one class of hydrocarbons. Olefins, in general, blend like naphthenes. Moreover, dicyclopentadiene again exhibits negative deviation from linearity. TEL increases positive deviation in all but one case. Leaded blends of *iso*octane and triptane exhibited an unexpected positive deviation.

A PHYSIOCHEMICAL MODEL

(Editor's Note: In the original paper, the author reviews past work 13, 14, 15, 16, 17, 18, 19, 20, 21 done to establish a physicochemical model for knock.)

Although it will be difficult to develop a detailed mechanistic picture of precombustion processes occurring in blends, nevertheless, we are in a position, even now, to postulate certain basic types of mechanisms to explain some of the characteristic recurring curves for hydrocarbons in match blends. For example, it has already been noted that olefins and naphthenes in paraffin match blends exhibit a maximum positive deviation when there is approximately 75 percent paraffin present. Now, as has been seen, these compounds (e.g., di-*iso*butylene and cyclopentane) are most likely to inhibit chemical reactions. Therefore, it is reasonable to take these systems as test cases.

If it is assumed that the paraffin match blend can be inhibited up to a limiting value of γ (susceptibility to initiation), the performance number of a blend, PN_{1-2}, may be represented by the equation:

$$\frac{100}{PN_{1-2}} = \alpha_1 V_1 + \beta_2 V_2 + \frac{\gamma_1 V_1}{1 + \delta_2 V_2} \qquad (1)$$

Where:

V_1, V_2 = volume fractions of components 1, 2.

β_2 = the reciprocal of the performance number of components 2 $\left(\frac{100}{PN_2}\right)$.

$\alpha_1 + \gamma_1$ = the reciprocal of the performance number of component 1 $\left(\frac{100}{PN_1}\right)$.

δ_2 = the inhibiting activity of component 2.

Note that $\alpha_1 + \gamma_1 = \beta_2$, inasmuch as the inhibiting hydrocarbon 2 is matched by the inhibited hydrocarbon 1. Equation (1) was derived from a highly simplified kinetic scheme. Each parameter could thus be related to either a rate constant or a ratio of rate constants in the kinetic analogue.

If this equation is fitted to a typical curve, e.g., blend 156, by "least square" method, all the parameters may be evaluated. Thus, for four selected blends we obtained the values shown in Table 3 (Figure 6). It is premature at this stage to discuss further the significance of the values of the parameters listed. Only the simplest cases have been handled in this manner to date. Nevertheless, this treatment does show promise. Eventually parameters representing inhibiting and sensitizing activities and susceptibilities will be evaluated for a large number of hydrocarbons by blending in appropriate match blends. Also (judging by the values shown in Table 3), the value of each parameter may have to be corrected for the severity level at which it is to be used.

Equation (1) is also applicable to cases where the deviation from linearity is negative. In such a case, γ_1 would represent the sensitizing activity of component 1, and δ_2 would represent the susceptibility of component 2 to sensitization ($-1 < \delta_2 < 0$).

P. P. McCall (Esso Research and Engineering Company) has used a similar equation:

$$PN_{1-2} = V_1 (PN)_1 + V_2 (PN)_2 + \frac{\alpha V_1 V_2}{1 + \beta V_2} \qquad (2)$$

Here *1-2* is the blend of components 1 and 2 of volume fractions V_1 and V_2, respectively; α determines the magnitude; and β determines the position of the maximum. At present, for reasons already stated, it is premature to choose between the two equations (1) and (2).

Original presentation was before the American Petroleum Institute, Division of Refining, Los Angeles, May 12, 1958.

LITERATURE CITED

[1] Table I to V, *18th Annual Report on API Project 45*, American Petroleum Inst., New York (1956).

[2] Research Memoranda, Ethyl Corp., Detroit: No. 52 (1952); No. 66 (1953).

[3] L. C. Beard, Jr. "Fundamental Research on the Antiknock Properties of Pure Hydrocarbons and Their Blends," paper presented to a session on fundamental research during the 37th Annual Meeting of the American Petroleum Inst., Chicago, Nov. 11 (1957).

[4] Forrest H. Blanding. "Report of the Blending Study Group," *17th Annual Report on API Project 45*, p. 15, American Petroleum Inst., New York (1955).

[5] Eric J. Y. Scott. "Report of the Study Group on the Knock Rating of Hydrocarbon Mixtures," *18th Annual Report on API Project 45*, p. 17, American Petroleum Inst., New York (1956).

[6] Eric J. Y. Scott. "Report of the Study Group on the Knock Rating of Hydrocarbon Mixtures," *19th Annual Report on API Project 45*, p. 11, American Petroleum Inst., New York (1957).

[7] W. Cornelius and J. D. Caplan. "Some Effects of Fuel Structure, Tetraethyl Lead and Engine Deposits on Precombustion Reactions in a Firing Engine," *SAE Quart. Trans.* 6 [3] 488-508 (1952).

[8] E. R. Retailliau, H. A. Richards, Jr., and M. C. K. Jones. "Precombustion Reaction in the Spark-Ignition Engine," *SAE Quart. Trans.* 4 [3] 438-51 (1950).

[9] Forrest H. Blanding. "Factors Affecting the

About the Speaker

Dr. Eric J. Y. Scott works on basic studies in engine combustion for Socony Mobil Oil Co., Paulsboro, N. J. He received a B.S. degree in 1945 and a Ph.D. degree in 1948 from Glasgow University, Scotland. From 1948 to 1950 he was with the National Research Council, Ottawa, Canada, as a N.R.C. fellow. Dr. Scott came to the U. S. in 1950, where he worked at the University of Notre Dame on radiation chemistry until 1952, when he joined Socony.

Blending of Octane Numbers," paper presented to the Division of Petroleum Chemistry of the American Chemical Soc. during a meeting in Cincinnati, April 4-7 (1955).

[20] *ASTM Manual for Rating Motor Fuels by Motor and Research Methods*, American Soc. for Testing Materials, Philadelphia (1956).

[21] H. E. Hesselberg and W. G. Lovell, "What Fuel Antiknock Quality Means in Engine Performance," *SAE Journal* 59 [4] 32-7, 43 (1951).

[22] These formulas are used in accordance with a revision to reference No. 10 proposed by ASTM Committee D-2; cf. "1957 Supplement to ASTM Manuals of Engine Test Methods for Rating Fuels," American Soc. for Testing Materials, Philadelphia (1957).

[23] N. D. Sanders, "A Method of Estimating the Knock Rating of Hydrocarbon Fuel Blends," *Report No. 760*, National Advisory Committee for Aeronautics, Superintendent of Documents, U. S. Government Printing Office, Washington 25, D. C. (1943).

[24] B. M. Sturgis, "Some Concepts of Knock and Antiknock Action." *SAE Trans.* 63, 253-64 (1955).

[25] A. J. Pahnke, "Engine Studies of Preknock Reactions," paper presented at the Symposium on Chemical Literature during a meeting of the American Chemical Soc., Dallas, April 8-13 (1956); *Literature of the Combustion of Petroleum*, "Advances in Chemistry" series 20, 202-16, American Chemical Soc., Washington, D. C. (1958).

[26] C. E. Boord, "Cool Flames and the Organic Reaction Mechanisms Involved in Their Formation," *ibid.*, p. 5-14.

[27] W. P. Hawthorne and E. J. Y. Scott, "Structural Factors Determining the Knocking Characteristics of Pure Hydrocarbons," *ibd.*, p. 187-201.

[28] P. L. Cramer and B. A. D'Alleva, "Blending Characteristics of Hydrocarbons," technical memorandum, private communication to API Research Project 45 Advisory Committee, Aug. 7 (1951).

[29] P. L. Cramer, "The Induced Liquid Phase Decomposition of Hydrocarbons." *J. Am. Chem. Soc.* 60 [6] 1406-10 (1938).

[30] P. L. Cramer and J. M. Campbell, "Combustion of Hydrocarbons: Free Radical Chain Reactions," *Ind. Eng. Chem.* 41 [5] 893-7 (1949).

[31] E. W. Malmberg, M. L. Smith, W. Lee, G. Myers, and I Lee, "Preflame Reactions of Blends of Hydrocarbons in a Motored Engine," paper presented to the Division of Petroleum Chemistry of the American Chemical Soc. during a meeting in Dallas, April 8-13 (1956).

TABLE NOTES

[a] *Identification number:* This number has three components. The first represents the number of the blend series. The second is the phase of the program in which the series was run. The third is the group number and represents the group of blend series run by one laboratory. Thus 101-2-7 reads: "series 101, phase 2, group 7."

[b] These performance numbers are check points.

[c] Audible knock was used to rate these blends.

[d] The value given is the mean of the values obtained by the differential method and the conventional ASTM method. Below 100, octane numbers are averaged; above 100, performance numbers are averaged.

[e] Carburetor cooling was necessary. Some boiling may have occurred.

[f] Engine was unstable during these runs.

[g] The blends required heating. The other blends in the series required carburetor cooling.

[h] Readings were made at increased compression ratio. This removed a compression pressure effect—noted for the 50- to 100-percent blends.

[i] 2-Methyl-1, 3-butadiene was difficult to run. Carburetor required cooling.

[j] This low rating was believed to be attributable to instability of knockmeter readings.

[k] These are not match blends.

[l] Match-blend composition for audible knock: 78 percent ethylbenzene, 22 percent isheptane.

Editor's Note: The original paper reported data on 196 blends. Some of these were omitted for brevity.

More About Fuels

Cool Flame Related to Knock. Cool-flame studies were made on various mixtures of pure hydrocarbons in the motored engine and in the cool-flame tube. Analyses by gas chromatography were done on the products of partial combustion and on the hydrocarbon and oxygen consumed. The results on n-hexane and 2, 3-dimethylbutane showed substantial chemical interaction occurs in the combustion of hydrocarbon blends. There is evidence these precombustion reactions are intimately involved in the performance of individual hydrocarbons and their mixtures in an internal-combustion engine. It is concluded that additional study of this type is needed before the basic chemical principles governing the interactions which occur among hydrocarbons can be delineated.

("The Behavior of Blends of Pure Hydrocarbons in Cool Flame as Related to their Deviation from Linear Blending on the Performance-Number Scale," C. E. Boord, J. M. Derfer, M. L. Smith, H. R. Menapace and G. Kyryacos, The State University, Columbus, Ohio.)

Chemical Reactions Tell. Considerable progress in understanding the causes of knock has come from a systematic study of the chemical reactions which occur prior to autoigniton. Recently, a spectrometer has been used to follow changes in the composition of the reacting fuel in the engine combustion chamber as pressure and temperature conditions which produce knock are approached, thus providing a means for studying pre-knock reactions as they occur.

The chemical reaction between unburned fuel and air which takes place in the unburned mixture prior to knock (1) releases heat and thereby increases the temperature and pressure of the unburned charge, (2) results in the formation of new chemical species, some more stable and others less stable than the original fuel molecules, and (3) results in the formation of highly reactive free radicals which are critical reactants in the auto-ignition process. The relative importance of each of the previous factors in the over-all knock process varies with hydrocarbon structure and engine conditions.

Tetraethyllead (TEL) is relatively ineffective in inhibiting the early preflame reactions which result in the formation of such well-defined oxidation products as peroxides, aldehydes, and ketones; however, it is extremely effective in inhibiting the critical free-radiacal reactions which cause auto-ignition.

("Studies of the Chemical Reactions Which Occur in an Engine Prior to Knock," K. J. Pipenberg, A. J. Pahnke, and R. H. Blaker, E. I. du Pont de Nemours and Co., Inc., Wilmington, Del.)

How Antiknocks Work. An increase of one octane number in the primary reference fuel series corresponds to an increase of about 1.3 percent in the length of time before its mixture with air will self-ignite when exposed to a high level of temperature and pressure.

Physical factors affect the action of antiknocks also. To suppress knock, metal-organic fuel additives must first break down into discrete particles of metal oxide. This decomposition also is controlled by temperatures and time.

Import factors controlling antiknock action include the size of the metal-oxide particles (which determines the surface area per unit of additive), the composition of the particle surfaces, and the ability of reactive substances in the fuel-air mixture to reach these surfaces (diffusion). The varying effectiveness of metal-organic antiknocks in different fuels may someday be explained on the basis of the structure of these particles and the changes they undergo.

("The Role of Physical Factors In Knock," E. B. Rifkin, Ethyl Corp., Detroit.)

Random Sample Reveals Carbon Steel Brittle at Ambient Temperature

A temperature of 100 F, or higher, is required before the danger of "low temperature" brittle failure becomes negligible.

F. B. Hamel
The Standard Oil Company (Ohio)
Cleveland

THE DATA currently available on the impact properties of vessel steels is either sketchy or nonexistent, *But:* 1. it has been established, as the result of actual tank failures, that conventional tank steels have impact properties such that low-temperature brittle failures (in tanks) are a *distinct* possibility; 2. in two recent failures of new major vessels, the impact qualities of the steel are suspected to have been an important factor in the *extent* of the damage which resulted; and 3. a minor failure of our own (Sohio) led to an investigation that showed steels in older vessels are also susceptible to low-temperature brittle failure.

This fact, that *all* carbon steels may be susceptible to low-temperature brittle failure, is the justification for the test work which is the subject of this paper. The testing program was designed to determine the impact properties of vessel steels in common usage and the ranges within which these properties vary. In so far as possible, factors which might determine these properties were also measured.

Test Results. The results of 161 random samples of vessel steels conclusively show that *ordinary* vessel steel *can be* brittle at *all ambient temperatures.* In addition, a temperature of 100 F, or higher, is required before the danger of a "low-temperature" brittle failure becomes negligible. Regardless of the criteria used for impact resistance, a sizeable percentage of all vessel steels have low-impact resistance at normal winter temperature. On the basis of this evidence, the code requirements for the use of impact-tested steels at operating temperatures below minus 20 F appear to be inadequate. From this data, and from our earlier tests on steel samples from older vessels, we believe that all of our vessels are susceptible to low-temperature brittle failures, provided that the other requirements for a brittle failure are present (a notch, high-stress, and low-temperature conditions).

The test program revealed that the range of impact resistance was *very wide;* for instance, the Charpy V-notch 15 ft-lb transition temperature varied from minus 60 F to plus 120 F. The important fact here is that almost any of these steels *can have good impact resistance.* This represents a major difference between the newer and the older vessel steels tested. *None* of the older vessel steels were found to have a high-impact resistance. If some of these steels can have high-impact resistance, why not all of them?

A preliminary analysis of our data shows a strong relationship between transition temperature and grain size. Thickness shows a similar relationship, but it also correlates with grain size. Both of these factors indicate that improvements in rolling practice and the associated temperature conditions would produce a major improvement in impact resistance. The data on the chemical elements measured is more complex, although it is apparent that silicon, copper, and manganese improve impact resistance, while carbon decreases it.

In reviewing the work that we have done, it is our opinion that this work should be continued and expanded as a cooperative effort by users of vessel steels, similar to the ship-failure work. This program should have the following objectives:

1. Provide a "clearing house" for data on low-temperature brittle failures. (The "little" ones as well as the spectacular ones.)
2. Collect, tabulate, and analyze data on the impact resistance of vessel and tank material, including the effect of operating time and temperature.
3. Promote improved impact resistance in all steels.
4. Justify improvements in code requirements.

Originally presented before the API Division of Refining, Los Angeles, May 13, 1958, under the title, "An Investigation of the Impact Properties of Vessel Steels (A Progress Report).

About the Speaker

F. B. Hamel graduated from Ohio State University with a B.S. degree in mechanical engineering in 1948. His first six years after graduation were spent with Standard Oil Co. (Ohio) in shop inspection and project and planning work. For the past four years he has been a materials and corrosion specialist in the Manufacturing department, General Engineering division, in new construction and refinery service activities.

Trouble-Shooting Delayed-Coking Units

A survey of 16 units revealed the most frequently encountered difficulties. Recommendations to remedy these troubles are given.

N. A. Weil and F. S. Rapasky
The M. W. Kellogg Company
New York City

MOST CURRENT refinery processes are essentially continuous in operation, involving steady use of equipment for relatively lengthy duration. Delayed coking, while continuous as a process, entails a periodic accumulation and removal of residual coke on a 24- to 48-hour cycle. During this period the temperature of the coke drums rises from ambient to approximately 800 F. and is then returned to atmospheric. The relatively frequent cycles of this operation magnify the effects of pronounced cyclic strains. As a result, numerous instances of equipment distress have been reported, some of which require extensive maintenance and corrective measures.

The purpose of this paper is to assemble the various problems encountered, trace their sources, and advance recommendations for their correction. In the course of this investigation the writers visited 16 delayed-coking units. The most frequently encountered difficulties can be listed as follows:

- Deformation and growth of shell.
- Irregular local warping of shell.
- Cracking of skirt attachment weld.
- Distortion of bottom manhole-neck flange.
- Weld cracking between bottom cone and manhole neck.
- Crack formation around nozzle attachments.
- Cracking of internal alloy lining.
- Dishing of the bottom cover.

The pertinent findings are assembled in Table 1: This table contains an itemized listing of operating difficulties encountered, their possible source and significance, and the manner of their elimination or minimization on present as well as future installations.

It must be appreciated that in any cyclic operation imposing the magnitude and variations of thermal stresses to which equipment in delayed coking is unavoidably subjected, maintenance will always be necessary. Frequent and close inspections are essential for minimizing potential troubles. Difficulties can best be brought under control by effectively tracing and analyzing their sources immediately after they are first detected.

Originally presented before the API Division of Refining, Los Angeles, May 13, 1958.

About the Speaker

Dr. N. A. Weil received a B.S. degree from Polytechnic University of Budapest in 1947, and M.S. and Ph.D. degrees from the University of Illinois in 1952. He is in charge of mechanical development activities of The M. W. Kellogg Co. on topics concerning fluid dynamics, mechanics, heat flow, stress analysis, and equipment design. He is the author of about a dozen technical papers and books, and is a member of the adjunct faculty of New York University.

More on Pressure Vessels

Steel Helps Petroleum Progress: Steel research has been criticized for being too concerned with its own processes and not enough concerned with those of its customers. This criticism may once have been warranted to some extent.

But now under study are these problems of interest to petroleum: developing better weldability in the A-387 chrome moly steels; production and forming techniques for corrosion resistant alloys in clad steel form; the value of ultrasonic testing as an inspection tool; the effects of hydrogen on the metallurgical properties of clad and alloy steels.

Standard steel specifications may need more prompt and more frequent modification in the future to meet individual customer requirements and permit more rapid development and acceptance of new materials. Every new product must demonstrate potential economic justification in both its market application and its manufacture to merit continuing development. Quenched and tempered plate is an example.

Continued and improved cooperation between steel and petroleum will result in better steel research to meet petroleum's needs.

("Research and Development—The Catalyst of Steel and Petroleum Progress," C. L. Huston, Jr., Lukens Steel Co., Coatesville, Penn.)

TABLE 1—Recommendations Relating to Operating Troubles on Delayed-Coking Units

Operating or Maintenance Difficulty	Source of Trouble	Significance or Potential Damage	Remedial Recommendations	
			Existing Installations	New Construction
Vessel growth and bulging.	Severe water quenching; excessive thermal gradients.	Reduction of vessel wall thickness; cracking of girth welds.	Ameliorate conditions of quenching; provide water-quenching time to raise UQF* above 0.80	Provide UQF = 0.80 for conventional transfer-line inlet arrangement. With transfer-line at center of bottom cover, UQF of 0.40 can be permitted.
Irregular local warping of shell.	Severe local overheating caused by fire.	None, unless permitted to occur frequently.	Overflow and drainage period of sufficient duration (at least 1 hour) to cool all portions of coke mass.	Enforcement of proper overflow period. No design changes necessary.
Cracking of skirt attachment weld.	Heat flow in skirt during operating cycle. Inadequate skirt - weld proportions.	Fire if crack penetrates shell wall. Inadequate support and possible overturning of drums if crack propagates around entire circumference.	Grind and improve weld contour and insulation. If cracking still recurs, slot skirt.	Use slotted skirt attachment and improved weld and insulation details. Calculate stresses for individual units.
Ovalization of bottom manhole-neck flange.	Uneven circumferential temperatures at flange.	Bottom cover cannot be headed up, requiring extended shutdown.	Use an alloy liner in the nozzle and refractory insulation to reduce stresses in the base metal.	Place transfer-line inlet nozzle in center of bottom cover.
Weldcracking between bottom cone and manway neck.	Uneven circumferential temperature distribution and sharp cone-cylinder intersection detail.	Welding, cracking, potential fire.	Control temperature by insulation and reduce stress concentration by rounding and grinding weld.	Knuckled cylinder-cone transition pieces of adequate radius with central inlet.
Crack formation around nozzle attachments.	Excessive circumferential thermal stresses.	Recurrent cracking, requiring repairs.	Use internal alloy insulated nozzle or equivalent thermal sleeve.	Use internal alloy insulated nozzle or equivalent thermal sleeve.
Cracking or pillowing of internal liner.	Inadequate attachment of cladding or lined or leakage behind liner.	Recurrent pillowing or cracking of lining, requiring repairs.	Reduce by lowering quench severity.	Use only integrally clad, submerged-arc, or spot-welded continuous liner.
Cracking of alloy overlay in main welded seams.	Cyclic thermal stresses caused by differential expansion.	Transverse cracking of weld seams, which may penetrate vessel wall if left unattended.	Replace 20-25 chromium-nickel with weld deposit having expansion coefficient close to base plate.	Use stainless weld overlay with expansion coefficient at or somewhat below that of base plate.
Dishing of bottom cover.	Thermal shock caused by condensate evaporation upon rapid switch-in of feed.	Bottom cover cannot be sealed tight.	Revamp piping to permit thorough drainage of condensate during heating-up cycle, or switch drums gradually on-stream.	Centrally located transfer-line inlet nozzle used for drainage of condensate.

$$*UQF = \frac{\text{water-quenching time (minutes)}}{\text{coke yield per vessel (tons)}}$$

New Test for Sediment

This test along with 11 other laboratory techniques was introduced in the Analytical Research session.

SOCONY MOBIL OIL Company is proposing a new method for determining sediment in fuels. The method can be applied to gasoline, jet, diesel and burner fuels. It is useful for filtration and storage stability studies where small amounts of sediment of the order of a few parts per million must be measured.

The sediment is filtered from a fuel sample and weighed on a filter paper made of glass fibers. These filter discs are commercially available and easy to use. The results are more accurate than those obtained with sintered glass or asbestos fiber filters.

The particle size of typical sediment was studied using filtration, centrifugation, and microscopic methods. The glass fiber paper removes particles down to 0.5 microns in diameter, which is fine enough to capture all of the sediment normally found in fuels.

Another advantage of the glass fiber disc is the low adsorption blank. Other filters with greater surface areas were found to adsorb soluble materials from the fuel, which tended to give high results. ("Accurate Determination of Sediment in Petroleum Fuels in the Parts-Per-Million Range," by F. A. Buehler, J. P. Kirchner and J. S. Wiberley, Socony Mobil Oil Company, Inc., Brooklyn, N. Y., and Paulsboro, N. J.

Lab Operations: At Esso, a computer simulates the operations of the laboratory. Because of its rapidity, the computer can duplicate an entire year's operation in about fifteen minutes. Factors which affect service time and laboratory costs are primarily the workload with its fluctuation and the number of men available to do the work. These factors can be described mathematically and a laboratory "model" programed in a computer. Many alternative ways of operating the laboratory can be tried in the model and a final analysis of the data produced will indicate the most efficient method of operating. This novel approach to studying laboratory operations becomes a powerful management tool. ("A Mathematical Approach to Operating an Analytical Laboratory," G. V. Dyroff and F. E. Steidler, Esso Research and Engineering Company, Linden, New Jersey.)

Other Sessions Covered Here

Training Session
Air Polution

Platinum in Catalysts: In buying platinum reforming catalyst, the exact platinum content becomes of extreme importance. For example, an error of 0.01 percent in determining the platinum content on the total charge to a typical reforming unit will mean about $10,000. This paper describes an X-ray spectrographic method for making a rapid and accurate determination of platinum reforming catalyst. Using this method an analysis can be completed in an elapsed time of about three hours, about 30 minutes of which requires the operator's attention. Data presented in the paper show the precision of the method to be about ±0.003 percent platinum. ("Quantitative Determination of Platinum in an Alumina-Base Reforming Catalyst by X-Ray Spectroscopy," A. J. Lincoln, Engelhard Industries, Newark, N. J. and E. N. Davis, Sinclair Research Laboratories, Harvey, Ill.)

Catalyst Analyses: A high-temperature induction furnace is used to speed catalyst analyses. Rapid combustion of these stable catalysts can be achieved by the intense heat generated in the induction coil. Temperatures of approximately 1,400 C. are obtained. Under these conditions the catalyst is completely decomposed and all volatile constituents can be trapped as they evaporate from the melt. Such materials as sulfur, chlorine, bromine, and fluorine have been determined in this manner. ("Induction Furnace Speeds Catalyst Analysis: Fluorine, Sulfur, Chlorine, and Bromine," A. L. Conrad, J. K. Evans and V. F. Gaylor, The Standard Oil Co. (Ohio), Cleveland, Ohio.)

Sulfur in Small Quantities: For many years a reliable method for determining 1 or 2 parts of sulfur in a million parts of sample has been needed.

This method, developed for the first time, allows the reliable determination of less than 1 part of sulfur in a million parts of sample. The method uses a specially prepared nickel catalyst which converts sulfur in the sample to nickel sulfide. Established methods of analysis determine the sulfur in the

nickel sulfide and the analyst then learns the sulfur content of the sample.

This method of analysis has been found very useful for determining very small amounts of sulfur in petroleum naphthas. ("Determination of Microgram Quantities of Sulfur by Reduction with Raney Nickel," Lawr. Granatelli, American Oil Co. (Texas), Texas City, Texas.)

Peroxide Determination: The classical iodometric methods for determining peroxide content are subject to several criticisms when they are applied to gasoline, oils, and other petroleum products. Perhaps the most important objection is side reactions giving rise to unreliable results. Also, other methods have the shortcoming that they determine only one peroxide type, namely, hydroperoxides. An improved method, employing an automatic titrator, has been devised for the determination of hydroperoxides and diacyl peroxides. In this method the sample is allowed to react with potassium iodide in a semi-aqueous medium and the liberated iodine is immediately and continuously titrated by the automatic addition of sodium thiosulfate solution. Thus, the iodine is never allowed to exceed a very small value and then only momentarily so that only peroxides are determined. This method has been used to determine the peroxide content of gasoline, jet fuels, and oils, as well as alcohols and a number of petrochemicals.

Socony is using the method and claims a standard deviation of about one milligram per liter between laboratories. ("The Automatic Titration of Peroxides in Petroleum Products," J. S. Matthews and J. F. Patchan, Gulf Research and Development Co., Pittsburgh, Pa.)

Petrochemical Impurities: Polymers and textiles can be influenced very markedly by only small changes in the chemical structure of petrochemical intermediates. A number of analytical techniques have been employed in characterizing these compounds. However, with one class of intermediates known as the mono- and polycarboxylic acids, some difficulty has been encountered by use of the more conventional methods.

In this technique the solid sample is compressed with potassium bromide into a pellet. This pellet, when placed in an infrared beam, can give information related to its contents by study of the transmitted infrared light. ("Quantitative Analysis of Monobasic and Polybasic Benzene Carboxylic Acids in Potassium Bromide Disc by Infrared Spectroscopy," D. E. Nicholson, Humble Oil & Refining Co., Baytown, Texas.)

C-H Determination: An efficient micro method has been developed for determining carbon and hydrogen automatically. As in the conventional method, the carbon and hydrogen are converted to carbon dioxide and water by combustion, but the tedious manual control of combustion has been replaced by an automatic process. In this procedure, the burning of the sample is controlled by pressure increases developed as a result of the combustion itself. A movable heater passes over the sample causing vaporization and production of gaseous products, building up the pressure within the combustion tube.

When the pressure reaches a predetermined maximum, the movement of the heater is stopped until the pressure is dissipated by the diffusion of the gases through a choking plug. The rate of flow of sample through the combustion tube is thus automatically controlled by electrical and mechanical devices, eliminating the attention of a skilled analyst.

The new method allows the operator more freedom during the combustion period, which results in greater production. Another advantage is the more precise control allowing more consistent results. ("Microcarbon and Hydrogen Determination by Automatic Combustion Control," Ervin Stehr, The Texas Co., Beacon, N. Y.)

Surface Area: A promising new method has been developed for measuring the adsorption of nitrogen in the determination of the surface area of solids. In this method the nitrogen is adsorbed by the sample at liquid nitrogen temperature from a continuous gas stream of nitrogen and helium and then eluted by warming the sample. The nitrogen thus liberated is determined by thermal conductivity measurements on the exit gas stream.

Close agreement in results is obtained with the conventional volumetric method for surface area measurements by nitrogen adsorption, and the precision appears equally good. The chief advantages of the new method are that it does not involve vacuum techniques and is therefore free of concomitant maintenance problems; it is simpler for routine application and less skill is required; a permanent record is automatically obtained. Also the method can be applied to samples of lower area—down to about 0.1 square meters per gram. ("Determination of Surface Area—Adsorption Measurements by a Continuous Flow Method," F. M. Nelson and F. T. Eggertsen, Shell Development Co., Emeryville, Calif.)

Bromide Numbers: A new instrument for the determination of the bromine consumption of petroleum products has been developed by the Phillips Petroleum Company, Bartlesville, Okla. The bromine consumption is a measure of the olefin content of refinery products. This new instrument is being used routinely to measure the olefin content of experimental products.

The instrument is based on the fact that bromine will react selectively with olefins in the presence of other hydrocarbons. The bromine is added to the sample by electrolyzing a solution of potassium bromide, which forms elemental bromine. The bromine is consumed as rapidly as it is produced as long as there is any olefin remaining in the solution. When all of the olefin has reacted, the bromine gives a yellow color to the solution. This appearance of color is detected by the decrease in the transmission of ultraviolet light through the solution. A sun battery is employed to measure this decrease in transmission of light. The exact concentration of bromine is read from a recorder which is attached to the sun battery. The amount of bromine consumed is then read directly from the recorder chart. ("A Photometric Titrator and Method for the Determination of Bromine Numbers with Electrogenerated Bromine," J. W. Miller, M. D. Grimes and B. J. Heinrich, Phillips Petroleum Co., Bartlesville.)

Exhaust Composition: The type of fuel burned by an engine affects exhaust composition in varying degrees depending upon engine condition, engine operation, and other unknown factors. The differences may—or may not—be important to the air pollution problem. The work that is reported was done to obtain factual data about: 1, chemical differences in the exhaust products from different fuels and, 2, how these differences were affected by engine speed and load.

Analytical data obtained by gas chromatography show that exhaust composition varies with engine speed and load according to consistent trends. These trends are influenced by fuel composition and the degree of fuel influence depends upon mode of engine operation; some basic fuel characteristics are more heavily reflected in the exhaust than are others. Generally, differences in the composition of exhausts from different fuels are quantitatively small but they are reproducible. These data cannot be construed as indicative that fuels do—or do not—differ in smog-forming potential. They outline chemical differences for the use of others who may: 1, determine which chemicals in the exhaust are important and, 2, study measures that may be taken to make exhaust gas ineffective as a smog producer. ("The Variable Influence of Automotive Fuel Type on Exhaust Composition," R. W. Hurn, Petroleum Experiment Station, Bureau of Mines, U. S. Department of the Interior, Bartlesville.)

Flame Tests: Many flame photometric analyses are most easily conducted with the sample dissolved in a hydrocarbon solvent. When such a solvent is burned, the flame emission contains strong bands due to the radicals C_2, CH, and OH. These frequently interfere.

The burners used produce diffusion flames whose properties vary widely along length and breadth. This study was concerned with the lengthwise variation.

It was found that radiation by C_2 and CH came almost entirely from the lower portion of the flame. The peak emissions of metals such as Na, Ca, Pb, B, and Ba occurred in the upper part of the flame. Therefore, by observation of the upper part only, the metal emission detected is free of interference by C_2 and CH. Fortunately, the emission by OH, which cannot be so easily avoided, occurs only over a small wave length region.

This paper describes the quantitative aspects of selected area emission and illustrates the advantage gained by masking an appropriate portion of the flame. ("Improved Flame Photometry by Direct Recording Study of Selected Flame Area Emission," H. D. Dubois and R. E. Barieau, California Research Corp., Richmond, Calif.)

Training Session—Needed: New types of managers

A RECENT survey of 2,000 members of the American Society of Training Directors revealed that executive and supervisory development is the greatest training need in American organizations.

Not only, however, is there a need for more managerial talents, but there is a growing recognition of the need for more well-rounded, wider-visioned persons in executive positions. For this reason, many firms are giving their executives a liberal arts education.

("The Expanding Scope of Executive Development," Robert F. Smith, Consultant, Los Angeles.)

Problem Recognition in Business: Problems exist in business, but they can only be recognized when objectives also exist. A business with no objectives has no problems other than staying out of the bankruptcy courts. In a capitalist economy such as ours, all private business units have one destination in common: they must make sufficient profit out of their activity to retain capital already committed and they must attract additional capital if that becomes necessary.

What then are the ground rules for this profit seeking? What will a business do to gain the profits necessary for its continuation, and what will it not do? Why does it choose this course of action and reject that one? Answers to these questions predetermine the kind of problem a business faces.

The actual problem recognition begins with the task of predetermining the conditions under which necessary profits will be sought. It culminates in articulating the conflicts which arise out of seeking profits within the framework of the ground rules adopted. These ground rules are that business operates in a community which believes in the sanctity and importance of the individuals, private property, and the rule of the law. The economic organization of our culture places primary responsibility on private business to provide employment for labor, capital for increased productivity, revenue for government and goods and services for consumers.

("Problem Recognition in Business," Laurence de Rycke, Occidental College, Los Angeles.)

Air Pollution Session—Oxidants damage flora

Oxidant plant damage from ozone-olefin reactions at low concentrations was studied in a dynamic stirred flow system incorporating a plant exposure chamber with a long-path infrared spectrometer. Reaction time and concentration of the fumigants were found to be as important, or perhaps more so, than olefin structure in determining formation of the phytotoxicant.

("Oxidant Plant Damage from Ozone-Olefin Reactions," Ellis F. Darley, John T. Middleton, University of California, Riverside, Calif., and Edgar R. Stephens, The Franklin Institute, Philadelphia, Penn.)

Atmospheric Conversion Tests: In the gaseous state, the sulfur dioxide is only very slowly oxidized to sulfur trioxide. It has been recently suggested that in the presence of fog and particulate-matter catalysts, this oxidation may be greatly accelerated. If oxidation does occur, both sulfate and acidity of the particulate matter should increase. Since nitrate is frequently also present in significant quantities, its relationship to acidity should also be known.

Techniques have been developed for testing this hypothesis in the Los Angeles area.

In this investigation the sulfur dioxide was usually very low in concentration and was not well correlated with sulfate levels. Other sources besides sulfur dioxide may be required to account for the sulfate levels found in the particulate matter. A large fraction of the particulate matter was found to be water soluble, particularly in the submicron fraction, and it contained acidity which could not be accounted for in terms of the sulfate and nitrate levels found.

("Investigations to Detect the Atmospheric Conversion of Sulfur Dioxide to Sulfur Trioxide," Albert L. Chaney, Albert L. Chaney Chemical Laboratory, Inc., Glendale, Calif.)

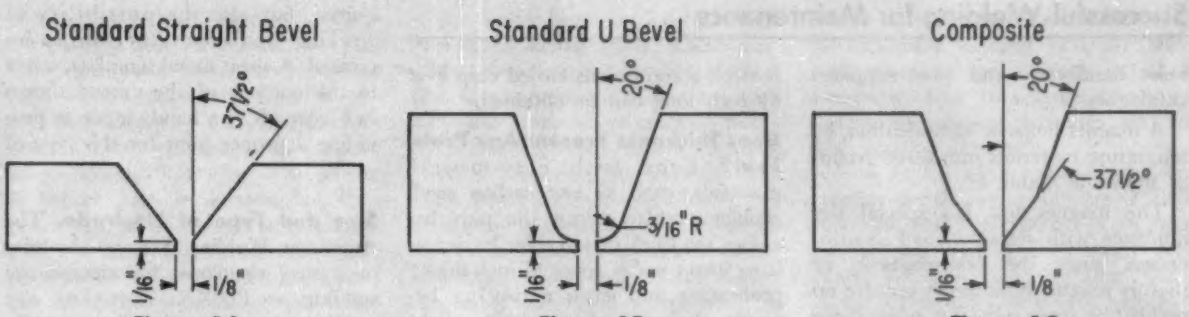


Figure 1A Figure 1B Figure 1C

FIGURE 1—The straight bevel is used on thin wall pipe while the U bevel and the composite works best on heavy walled pipe.

Successful Welding for Maintenance

Have you ever tried to weld where the composition of the base metal was unknown? Here's how to determine what the metal is and the proper electrode to use.

Ray M. Kolb
Standard Oil Company of Indiana
Whiting, Indiana

MAINTENANCE BRINGS many diversified welding problems. Under service conditions, metals wear, corrode, erode and fail in numerous other ways. Many times welding is called upon to repair this damage so that a badly needed plant or machine can be put back in operation. When such a job arises there are some fundamental questions that should be answered to assure a successful welding job:

- What is the base metal to be welded?
- Does the thickness or geometry of the part present any problem?
- What size and type of welding electrode or filler metal should be used?

What Is the Base Metal? It pays big dividends to keep accurate material records of the parts in your plant that may some day require welding. These records can best be obtained at the time equipment is purchased or built. One must be careful, however, to avoid ambiguous descriptions such as "stainless steel," "brass," "aluminum," or "alloy steel." Many different types fall into each of these broad classifications. Practically all of these metals can be welded if their composition is known, but can cause considerable difficulty if a guess is made as to the material being welded.

For example, the occasion might arise requiring a repair weld on a part known only as stainless steel. It could be any one of many types, varying from a readily weldable material like Type 304 (18 chrome 8 nickel) to a difficult to weld, air hardenable material like Type 420 (12 chrome over .15 carbon).

To get an accurate metal identification would require a spectrographic or a quantitative chemical analysis. However, such analyses are expensive and usually it is not practical to wait long enough for such an analysis to be made. There are a few simple tests, however, that can provide an idea of the metal composition.

Observation of the shape, weight, color and scale or rust formation on a part gives the first clues as to composition. By the shape of a part, one can differentiate between castings, forgings, extrusion, plate, pipe, etc. Weight allows us to differentiate between the light materials such as aluminum and magnesium and the iron and steel materials. Color characterizes most copper base alloys. Scale and rust formation frequently segregate the plain carbon or low alloy steels from the stainless types or the high nickel copper alloys.

Spark testing can often be helpful. Iron base or ferrous materials throw off a characteristic spark stream when held against a grinding wheel, while the non-ferrous materials such as copper, aluminum, and nickel-base do not yield any appreciable spark. Testing is best done in a shaded area where the color of the spark stream can easily be seen. A medium or small grained grinding wheel turning at ordinary operating speeds produces a satisfactory spark. Best results are usually attained by comparing the spark from the unknown material with known samples. Care must be taken to use the same speed and contact pressure since the length of the stream will vary if either is changed. Welding rods are sources of sample material, but care must be taken in using coated electrodes, as a comparison metal, since alloying agents are frequently added through the coating. Spark testing charts are included in

most handbooks and steel suppliers catalogues.

A magnet helps in identification, by separating materials into three groups as shown in Table 1.

The magnet test has special significance with stainless steel identification, since the non-magnetic or slightly magnetic materials require no preheat or stress relieving, while those that are magnetic do require it.

A nitric acid spot test is another way to get some idea of composition. A drop will not affect stainless steel or stainless iron but will produce a green or blue-green color with monel or copper-nickel and a brown color with low carbon steel.

Chisel testing is frequently used to determine if a part is made of gray cast iron, malleable iron, or steel. This identification can readily be made with a sharp-edged chisel and a hammer. By trying to cut a continuous chip (not over 1/16 inch thick) we can tell which of these metals is involved. With cast iron it is not possible to obtain continuous chip, as it keeps breaking. In the case of malleable iron, a short, slightly curved chip is obtained. It is difficult to obtain chips longer than æ inch with malleable iron. However, if the piece tested is steel, a continuous curled chip over ½ inch long can be obtained.

TABLE 1—Magnetic Properties

Group I—Strongly Magnetic
1–Carbon and Low Alloy Steels
2–Wrought Iron
3–Cast Iron
4–Pure Nickel
5–Stainless Irons (Under 17 percent Chrome)
Group II—Slightly Magnetic
1–Stainless Steel (18–8 Types when cold worked)
2–Monel
3–High Nickel Alloys
Group III—Non-Magnetic
1–Stainless Steel (18–8 type annealed)
2–Copper Base Alloys
3–Aluminum Base Alloys
4–Zinc Base Alloys

TABLE 2—AWS-ASTM Classification of Steel Welding Rods for Acetylene Welding

Welding Rod Classification Number	Plate Thickness (Inches)	Treatment of Welds (a)	Tensile Strength PSI	Minimum Elongation in 2 Inches, in %
GA 65	¼	SR	65,000	20
		NSR	72,000	17
GA 60	¼	SR	60,000	25
		NSR	62,000	20
GA 50	¼	SR	50,000	28
		NSR	52,000	23
GB 65	¼	SR	65,000	18
		NSR	72,000	15
GB 60	¼	SR	60,000	20
		NSR	62,000	15
GB 45	¼	NSR	45,000	..

(a) S.R. designates stress relieved
N.S.R. designates not stress relieved.

Does Thickness Present Any Problem? Even with easy-to-weld materials, such as low carbon steel, problems arise when the part becomes too thick or too thin. In depositing heavy welds (over ¾ inch thick) preheating and stress relieving becomes desirable. In welding light gage sheet steel, burning through becomes a problem. Close fit-up, clamping the joint down tight and the use of a copper backing assist in accomplishing the job. It is a good practice to review carefully work that is over ¾ inch thick or under 3/32 inch, rather than leaving the problem completely to the welder.

The geometry of a welding joint design can have considerable bearing on the success of the job. As a general rule, the type of joint most desired is the one that will permit satisfactory welding at a minimum cost. Pipe under ¾ inch in thickness is usually welded with the type of bevel shown in Figure 1A. It consists of a 60- or 75-degree included angle and a ⅛-inch land. This joint is simple to prepare, either by flame cutting or machining. Where thicknesses are greater than ¾-inch, the joint becomes wider than is needed for accessibility and it requires considerable time to weld. To reduce welding time on heavier walled pipe, the type of joint design shown in Figure 1B is used. The thin section at the root of this joint gives some difficulty with burn-through when arc welding. This difficulty is not encountered when using the joint shown in Figure 1A and has led to the compromise shown in Figure 1C, which is very popular for heavy walled pipe welding.

In chipping or gouging out cracks to be repair welded by electric welding, care must be exercised to get a proper sized groove. It must provide accessibility but if it is too big, not only is more welding time required, but also the possibility of cracking and/or distortion is increased. A sheet metal template, made to the contour of the groove shown in Figure 1B, is a handy guide in providing a proper joint for this type of work.

TABLE 3—Suffix for Chemical Analysis of Low Alloy Steel Analysis

Suffix	Carbon Percent	Molybdenum Percent	Chrome Percent	Nickel Percent
A 1	0.10	0.45 to 0.65	....	....
B 1	0.10	0.40 to 0.65	0.40 to 0.65	....
B 2	0.10	0.40 to 0.65	1.00 to 1.50	....
B 3	0.12	0.90 to 1.20	2.00 to 2.50	....
C 1	0.12			2.00 to 2.75
C 2	0.10			3.00 to 3.75

Size and Type of Electrode. The American Welding Society identifies mild steel electrodes for electric arc welding as E60XX. E means arc welding electrode, 60 represents 60,000 pounds-per-square-inch minimum tensile strength of as-deposited weld metal, and the third digit, shown only as X, designates the positions in which the electrode is suitable to weld. The fourth digit tells the power supply required, penetration, type of arc, and weld quality.

There are 13 coated mild steel electrodes carrying AWS classifications; they are: E6010-11-12-13-14-15-16-18-20-24-27-28 and 30.

E6010 electrodes are probably the most popular in maintenance work. They are for use with direct current and reverse polarity only. The thickness of the coating is held at a minimum to aid in welding in the vertical and overhead positions. The arc is forceful and deeply penetrating. This is a key feature in maintenance work where it is occasionally necessary to weld on somewhat dirty or rusty surfaces. E6010 electrodes, with their deep penetration and voluminous gas shield, usually dig through slag and produce a satisfactory weld.

E6010 electrodes are excellent for pipe and structural welding. Although they are probably the best suited for general maintenance work, many applications can be found where other mild steel types can be employed for improved mechanical properties, faster welding speeds or reduced welding costs.

E6011 electrodes are for use with alternating current, as well as direct current, reverse polarity. With alternating current, they are comparable in performance to the E6010 electrodes; however, some sacrifice in usability characteristics will be observed when E6011 electrodes are used with direct current, reverse polarity. The E6011 electrodes are particularly useful for weldments which include corner welds and similar locations where arc blow is encountered with d.c. welding.

E6012 electrodes are intended for general purpose welding where deep

penetration is not desirable. They burn with a quiet, stable arc, produce little spatter and completely cover the weld with a dense but easily removable slag deposit. The E6012 electrode is often referred to as a "poor fit-up electrode" because of its ability to bridge gaps in irregularly fit-up joints such as are found in structural and machine weldments. This light penetration quality sometimes allows the successful welding of low alloy steels, since the weld bead does not dilute with enough alloy or carbon steel from the base metal to crack. While the E6012's are all position electrodes they are used primarily in the flat and horizontal positions. In vertical or overhead welding, the electrode used is frequently one size smaller than if an E6010 or E6011 electrode were used. The E6012 electrodes operate best with direct current, straight polarity, but they can be used with alternating current.

The E6024 electrodes are iron powder modifications of the E6012 electrodes. Their deposition rate for comparable sizes is approximately twice as great and their ease of handling and the excellent weld appearance assures good operator acceptance.

The E6013 electrodes are available in two modifications. One variety is an excellent all position sheet metal electrode. The second variety is used on heavier applications such as field erected storage tanks. These electrodes are easy to use, having little tendency to undercut, produce practically no spatter and have an excellent weld appearance. As in the case of E6012 electrodes, the penetration is light and the arc is soft.

The E6014 electrodes are iron powder modifications of the E6013 electrodes. They have a higher deposition rate, even, easier slag removal, and have an excellent weld appearance.

The E6015 and E6016 electrodes are known as low hydrogen electrodes. The E6015 is a direct current, reverse polarity electrode while the E6016 is its alternating current counterpart. Experience has shown that the performance of the E6016 electrode on direct current reverse polarity is entirely satisfactory and consequently E6015 electrodes are dropping out. The low hydrogen electrodes became available after World War II. Keeping free hydrogen in the arc zone low had proved to be a successful solution to the under-bead cracking problem in welding armor plate. These electrodes have found extensive application in maintenance. They are used for repair work where cracking might be a problem and where excellent physical properties are desired. High sulfur steels are best welded with low hydrogen electrodes. Free machining steels usually contain sulfur, which causes porous welds when other electrodes are used. Care must be taken with low hydrogen electrodes or they will pick-up atmospheric moisture. Suppliers usually pack them in moisture proof containers, but once the container is opened, the electrodes can pick up sufficient moisture in several hours to cause detrimental results. There are two solutions to the problem. One is to buy the electrode in small containers so that once opened it is quickly used. The other is to keep the electrode in a heated oven after it is opened. If the electrode does pick-up moisture, it can be dried out by baking at 600 to 700 F. for several hours.

The E6018 electrodes are iron powder varieties of the E6016 electrodes which give higher deposition rates with the same high quality.

The E6020 and E6030 electrodes are commonly referred to, by welders, as "hot rods." The E6020 electrodes are used for horizontal fillet welds and for flat position groove and fillet welds. The E6030 electrodes have a somewhat higher deposition rate than the E6020 electrodes and are used only for flat position work, primarily groove welding in heavy steel plate. These electrodes were used extensively in structural welding and for tank and pressure vessel welding but they are giving way, to a large extent, to automatic welding processes and to iron powder electrodes.

The E6027 electrode is an iron powder modification of the E6020 electrode while the E6028 is an iron powder low hydrogen electrode primarily for downhand welding. Both of these electrodes offer very high deposition rates, especially for flat position fillet welds.

Welding rods available for acetylene welding of mild steel are listed in Table 2. The letter G designates it as a gas welding rod. The two numbers shown give the tensile strength in thousand pounds per square inch. A second letter, A or B, refers to the degree of elongation. Grade A has a slightly higher elongation than B.

For Low Alloy Steels. The American Welding Society electrode designation system, previously explained while discussing mild steels, also applies to the low alloy materials. However, since the tensile strength of some of these materials is higher than 100,000 psi, it may require the first three digits to designate it. For example, an E12016 would be a low hydrogen type electrode with a 120,000 psi tensile strength.

In low alloy type electrodes, a welder is usually interested in knowing the chemical composition so that he can match the base metal chemistry. Table 3 shows the designations to

TABLE 4—Simplified Chemical Composition of Stainless Steel Filler Metal

AWS—ASTM Classification No.	Carbon Percent	Chromium Percent	Nickel Percent	Molybdenum Percent	Columbium PLUS Tantalum (Percent)
E 308, ER 308	0.08 max.	19	9	.....	.....
E 308 ELC, ER 308 L	0.04 max.	19	9	.....	.....
E 309, ER 309	0.15 max.	25	12	.....	.....
E 309 Cb	0.12	25	12	.....	0.7–1.0
E 309 Mo	0.12	25	12	2–3	.....
E 310, ER 310	0.20 max.	25	20	.....	.....
E 310 Cb	0.12	25	20	.....	0.7–1.0
E 310 Mo	0.12	25	20	2–3	.....
E 312	0.15	29	9	.....	.....
E 316, ER 316	0.08 max.	18	12	2–2.5	.....
E 316 ELC, ER316 L	0.04 max.	18	12	2–2.5	.....
E 317, ER 317	0.08	18	12	3–4	.....
E 318	0.08	18	12	2–2.5	6xC min. to 1.00 max.
E 330, ER 330	0.25 max.	15	35	.....	.....
E 347, ER 347	0.08	20*	10	.....	8xC min. to 1.00 max.
E 410, ER 410	0.12 max.	12	.....	.....	.....
ER 420	0.25–0.40	12	.....	.....	.....
E 430, ER 430	0.10 max.	16	.....	.....	.....
E 502	0.10 max.	5	.....	0.45–0.65	.....

*Chromium shall be 1.0xNi. min., when so specified.

cover chemical analysis of electrodes. While a complete classification number for mechanical properties alone would be E7010, a classification to cover chemical analysis also would be E7010-A1.

For Stainless Steels. Table 4 lists the many different types of stainless steel filler metals and their composition. A glance at this list shows how inadequate it is merely to describe the metal part as made of stainless steel. This tabulation not only includes the coated electrodes for arc welding but also includes the bare wires for acetylene submerged arc, or inert gas welding. The prefix E refers to metal arc electrodes, while the prefix ER designates a bare wire that could be used as an electrode for either the submerged arc or metal inert gas process or as a rod for acetylene or tungsten inert gas welding. The number following E or ER is the AISI stainless steel type number. The suffixes ELC and L both signify extra low carbon content. Two other suffixes, Mo. and Cb., represent the addition of molybdenum and columbium respectively. The coated electrodes use much the same designation system as for mild steel electrodes except that the A.I.S.I. number is substituted for the digits representing tensile strength. For example, in an E310-15 electrode, the E means it's an electrode, the 310 says it is an AISI type 310 stainless steel and the 1 and 5 have the same meaning as explained in Figure 1A and 1B for mild steel.

The type 308 filler metals are used to weld the 18-8 grades of stainless steel (AISI Types 301-302-302B-304-305 and 308.) There is little difficulty in welding these materials. Type 303 is the free machining grade of 18-8 and it gives more welding trouble since the addition of sulphur or selenium tends to evolve gas.

Carbide precipitation at the grain boundries tends to occur when many stainless steels of the 300 series are exposed to temperatures in the range of 900 to 1500 F during fabrication or service. This results in impaired corrosion resistance. Carbide precipitation is resisted by keeping the carbon content low or by adding columbium which combines with the carbon. Proper annealing can restore the original corrosion resistance, if it is practical to do so.

Type E309 and E310 electrodes join metal of their own composition without difficulty; however, they are both widely used to join dissimilar materials. An example would be joining Type 308 stainless to mild steel. These electrodes have both been very successful in welding hardenable steels without cracking. However, there can be little doubt that the heat affected zone is extremely hard when this is done. Type E309 and E310 have been used to attach type 405 and type 410 strip liners to refinery vessels without preheat or stress relief.

Type 410 and 420 stainless steels present a problem because of their air hardening tendencies. Both preheating and stress relieving are essential to achieve sound welds and serviceable ductility.

The 5 chrome, ½ moly filler metal (E502) finds wide use in refinery piping systems. It is also air hardening and requires preheating and stress relieving.

For Cast Iron. Cast iron presents many difficult, maintenance welding problems. It can be repaired, using the acetylene welding process, either by welding or by brazing. The electric arc process, using either a copper or a nickel base welding electrode, can also do a satisfactory repair job.

To acetylene weld cast iron, the entire casting must be preheated to a temperature of around 800 to 1100 F. Temperatures as high as 1,400 F might be required on larger castings. The usual practice, with large castings, is to build a fire brick furnace around them and preheat with gas burners or with a charcoal fire. A filler metal, designated as R-CI, which is a bare wire, cast iron rod, is used. The area to be welded is preheated to a dull red color, and the filler rod is heated and dipped in a powdered flux. The base metal and the filler wire are then "puddled" together in the proper proportions, adding flux as necessary. Arc welding could also be done with an E-CI coated, cast iron electrode and with the casting preheated in the same manner. After welding, the casting must cool slowly or cracking will result. In the case of large castings, the parts should be left in the furnace and the heat source gradually cutoff. Smaller parts can be covered with powdered asbestos or covered with lime and sand. Weld deposits made in this manner are readily machinable.

Brazing with copper base materials is a very effective method of cast iron repair. These materials are soft and ductile at high temperatures and give readily as the cast iron cools. As the filler metal temperature falls the last few hundred degrees, it reaches its proper strength level. The RCUZ$_n$-C (low fuming bronze) does an execellent job. The casting need not be preheated as high as for cast iron welding since it is only necessary for the base metal to reach a cherry red heat for brazing. Slow cooling, of course, is necessary. The copper base electrodes designated can also be used for cast iron repair.

Table 5 lists four nickel base welding electrodes available for cast iron welding. Preheating and slow cooling are common procedures when using these electrodes. However, successful welds can be made cold, if the casting is clean and free of "soaked-in" oil. Care must be taken in cold welding not to build up excessive temperatures, or cracking from thermal expansion will result.

Presented originally before the Ninth Plant Maintenance and Engineering Show and Conference, Chicago, January 27, 1958. ##

TABLE 5—Nickel Base Electrodes Used for Cast Iron Repair

AWS—ASTM Classification	Nickel Percent	Copper Percent	Iron Percent	Silicon Percent	Manganese Percent	Carbon Percent
E Ni	98.0	0.50	0.50	0.75	0.50	0.15
E Ni Fe	56.0	0.50	41.75	0.50	1.00	0.25
E Ni Cu-A	58.0	36.20	2.50	0.75	2.25	0.30
E Ni Cu-B	68.0	26.20	2.50	0.75	2.25	0.30

Treat Wastes With Dissolved Air

Here's a method of refinery waste treatment that combines chemical flocculation and dissolved-air flotation.

William J. Katz
Chain Belt Company, Milwaukee, Wis.

CONSTITUENTS in refinery waste water which may pollute a receiving body of water can be classified into three categories:

1. Suspended matter.
2. Emulsions.
3. Soluble matter.

Whether one or more of these should be removed depends upon conditions in each refinery and in the receiving body of water.

Generally, a gravity separator[1] is used to remove up to 90 percent of the suspended matter such as free oil, clays, silt, grit, chemical precipitates, etc. The gravity separator will not remove emulsions or soluble material and secondary and tertiary treatment means must be used.

Dissolved-air flotation is now being used in some refineries as a secondary treatment means following gravity separation. Dissolved-air flotation may be used to obtain additional removal of suspended matter above that obtained by gravity means. In one series of pilot plant tests[1] an additional average oil removal of 62 percent was obtained.

If further clarification and removals are required, chemical flocculants may be used in conjunction with dissolved-air flotation. In the series of pilot plant tests mentioned above, an additional average oil removal of 79.2 percent was achieved when using chemicals. Suitable chemical treatment may also remove emulsions and some of the soluble organic matter. This is accomplished by precipitating and coagulating the emulsified and soluble organic material. The coagulated particle may be floated by the attachment of air bubbles.

Dissolved-air flotation is a process for removing suspended matter from water, using minute air bubbles which have a diameter of approximately 100 microns or less. The minute bubbles are adsorbed onto the suspended particle, thereby reducing the effective specific gravity to less than that of water. The reduction of the effective specific gravity causes the particle to separate at a higher velocity in an upward direction. Stokes' Law[2] describes the factors affecting the rate of separation of a particle in water.

$$v_t = \frac{g\,(\rho_l - \rho_p)\,D^2}{18\mu}$$

where D = diameter of the particle
g = gravity constant
ρ_l = density of the liquid
ρ_p = density of the particle
μ = viscosity of the liquid
v_t = rate of rise of the particle

It may be seen in the above equation that the rate of rise is directly proportional to the difference in the density of the liquid and of the particle. The air-suspended particle floats to the surface of the liquid and is removed by a suitable means.

The mechanism attracting and holding the air bubble to the suspended particle may be considered an adsorption phenomenon.[2] The adsorption characteristics of the particle surface is a primary factor in the successful operation of the flotation process. Chemical agents can be added to change these adsorption properties. In waste treatment, however, the addition of these agents is not economically feasible.

Stokes' Law also states that the rate of rise of the particle is proportionate to the square of the diameter of the particle. The suspended particle size can be increased by the addition of suitable coagulating and flocculating chemicals. The suspended material is adsorbed, trapped or chemically united with the precipitated floc particle which forms. One or more of the above attachment mechanisms of the bubble on the suspended material in the floc particle may contribute to the coalescence of suspended matter in water. Such chemicals as alum, ferrous sulfate, ferric sulfate, ferric chloride, lime and copper sulfate are commonly used flocculants.

When chemicals are added, a second effect is the precipitation of soluble emulsified and colloidal matter. The degree of removal of these materials depends on environmental chemical factors and the type of coagulant used. Generally, the removal of soluble organic material other than oils may not be anticipated through the addition of chemical flocculants. Biological treatment is generally used to effect removal of these soluble organic compounds.

Flocculation as a step preceding flotation reportedly contributes to the effectiveness of the flotation process when chemicals are used.[3] The term flocculation here implies a process with sufficient reaction time for precipitation and particle growth under controlled agitation. Wullschleger and Katz[3] have reported average particle

size increase as flocculation time is increased. This effect may be noted in Figure 1. They have also demonstrated that the rate of rise increases with particle size as shown in Figure 2. Therefore, adequate flocculation will result in high separation rates.

It was also shown that more alum was removed as the flocculation time was increased. Figure 3 is a plot of floc removal versus mixing or flocculation time at constant chemical dosages. Notice that for a constant amount of chemical dosage, the floc removal increased with an increase in mixing time. In summary, flocculation as an adjunct preceding flotation may increase the separation rate of the chemical precipitate. In addition, fuller utilization of the coagulants may be achieved resulting in lower chemical dosages and chemical costs.

The process elements of dissolved-air-flotation are pressurized aeration, formation of air bubbles of suitable size and the flotation of the suspended matter. A major difference among commercial flotation systems is the method for introducing air into the system. In some systems, air is dissolved directly into the raw waste. In other systems, a portion of the effluent from the flotation tank is recycled and the air is introduced into the recycled stream.

In the first method, theoretically more air may be dissolved and a smaller tank volume may be required.

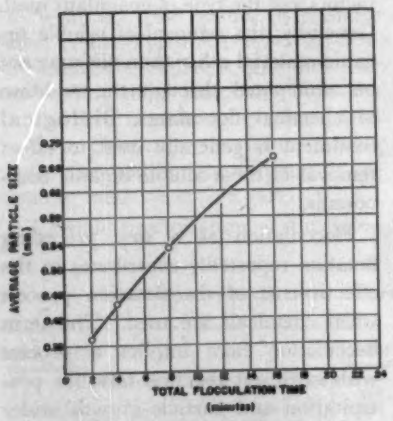


FIGURE 1—Longer flocculation time increases average particle size in a solution of 125 ppm alum—10 ppm bentonite.

The second method requires a smaller pump and less pumping costs. Also the second method of air injection avoids the tendency for emulsification of oils and greases resulting from the pumping action which is necessary to put the waste under pressure. Air injection in the recycle stream permits the use of a flocculation basin preceding flotation without pumping the flocculated materials. The pumping action may break-up the floc.

Figure 4 shows a flotation system utilizing recycled effluent for introducing air into the flotation system. The process water (raw waste) first may be treated with chemicals (if necessary) or may flow directly into the flotation tank without chemical treatment. In the mixing zone, waste is mixed with recirculated effluent containing minute air bubbles. The mixture passes through a vertical-slotted baffle and the suspended matter, with minute air bubbles attached, rises in the flotation tank.

In the flotation tank proper, the suspended matter separates and forms a scum at the water surface. The clarified effluent is withdrawn as an underflow. A portion of the effluent is recycled. The amount of recycle varies from 20 to 50 percent of the raw flow.

The recycled effluent is pressurized to 30-50 psig with a centrifugal pump. The amount of air which may be dissolved increases with the recycle rate and with the process pressure. With a process pressure of 40 psig, 0.5 to 1.0 scf of air is required per 100 gallons of recycle flow. After air injection, the air-water mixture flows to an air-water solution tank where the air is permitted to dissolve into the water. Various pressure vessel designs have been used and any mechanism producing more air-water surface will increase the solution rate. Generally, the process air requirements are a function of the method of air injection, the detention time within the air-water solution tank, design of the solution tank, the process pressure and the temperature of waste. The excess air is bled off from the pressure tank through a suitable mechanism.

From the pressure tank, the recycle stream which contains the dissolved air, flows through a pneumatic pressure control valve which has three functions.

1. Control of the process pressure.
2. Control of the recycle rate of flow.
3. Provides turbulence necessary to break the air-water solution at the reduced pressure and form the minute bubbles.

Turbulence along with a reduction in pressure is necessary to avoid separation of the air in water.

The recycle stream flows through a distribution header and mixes with incoming raw waste. The combined flow remains in the mixing zone for 30 to 60 seconds. Here the minute bubbles attach themselves to or form on the suspended material. From the mixing zone, the mixture flows through a vertical-slotted baffle into the flotation tank.

The flotation tank and its auxiliaries are as shown in Figure 4. The same principles as proposed in the American Petroleum Institute "Manual for Oil-Water Gravity Separators" are used to design the flotation tank. The rate of rise is determined in the laboratory and with the proper application of the turbulence and short-circuiting factors a tank size may be determined.

As with all waste treatment processes, flotation does not have universal application. Where flotation is applicable, the detention times are much less than those for gravity separators to obtain equivalent results. Gener-

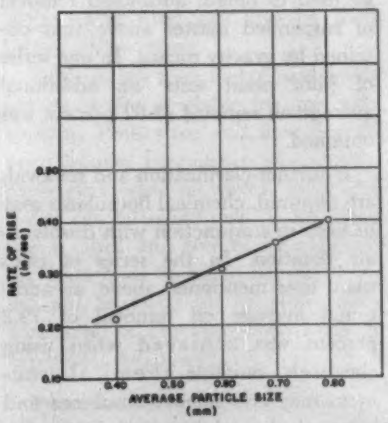


FIGURE 2—Rate of rise increases as average particle size increases in a solution of 100 ppm lime—20 ppm bentonite with 20 percent recycle.

ally, the design detention time required for flotation varies from ten to twenty minutes. This range of detention time is low compared to that required for gravity systems. Gravity separators usually require from 40 to 90 minutes holding time.

A second advantage of dissolved-air flotation is consistent separation results. Chemical flocs may settle, float or not separate in a gravity system because of variation in the quantity of oil associated with the floc particle. The suspended particles, with a bubble attached, will consistently float. A third advantage is the possibility of using lower chemical dosages. Chemicals need not be added to increase the gravity of the floc required in gravity systems to obtain equivalent separation rates.

A typical refinery waste is difficult to define. The chemical composition of the waste water flowing from each refinery is different. These variations also occur in and varies with production changes. The method and degree of treatment obtainable from a flotation unit will be influenced by the constituents and variation in waste water characteristics. For example, sulfides in a waste water may increase the chemical dosages required for treatment. The optimum pH for chemical treatment will be different for each refinery.

Bench scale studies must be used to determine if dissolved-air flotation is a possible treatment for a given refinery waste. These studies should be conducted over a sufficient period to obtain the effect of the waste variations on the degree of treatment obtained. The degree of treatment and the characteristics of the waste will determine whether chemicals are required. Portable flotation test kits are available for determining the effectiveness of flotation on a batch basis.

If the bench scale tests indicate that chemical treatment is necessary, the most effective flocculant, flocculant dosage, and optimum pH value may be determined. After the selection of the flocculant has been made, jar tests may be performed to determine the optimum chemical dosage, optimum flocculation time, and optimum pH.

In many instances, pilot plant work is indicated to determine the degree of treatment which may be anticipated from dissolved-air flotation. With pilot plant work, it is possible to predict more accurately the variation in performance of a prototype unit. Pilot plant work is usually indicated when large variations in the treatment properties of the waste occurs. These variations may be over a day or longer periods of time. Most manufacturers of flotation equipment have these pilot plants available.

In summary, dissolved-air flotation is a possible secondary treatment means for the treatment of refinery wastes. Chemical treatment may be used preceding flotation to achieve higher degrees of removal. Flocculation as a separate step preceding flotation appears to be advantageous. Universal application of dissolved-air flotation is not indicated. The waste water treatment for each refinery must be judged on its own merits.

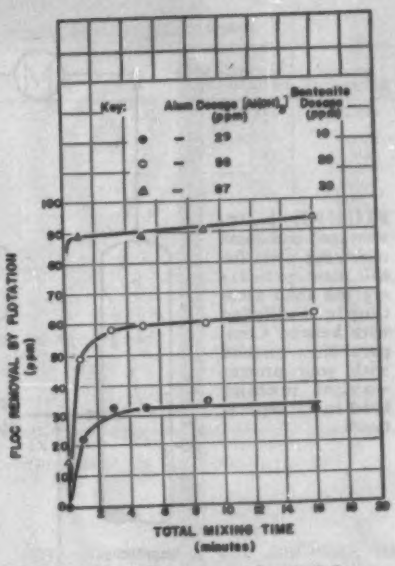


FIGURE 3—At constant chemical dosage, here is how mixing time affects flocculation and removal of alum-bentonite floc.

LITERATURE CITED

[1] Rohlich, G. A., "Application of Air Flotation to Refinery Waste Waters," *Industrial and Engineering Chemistry*, Vol. 46, February, 1954.

[2] Brown, G. B., Unit Operations, John Wiley & Sons, Inc., New York (1950).

[3] Katz, W. J., and Wullschleger, R., "Studies of Some Variables Which Affect Chemical Flocculation When Used With Dissolved-Air Flotation," presented at the Purdue Industrial Waste Conference, May, 1957.

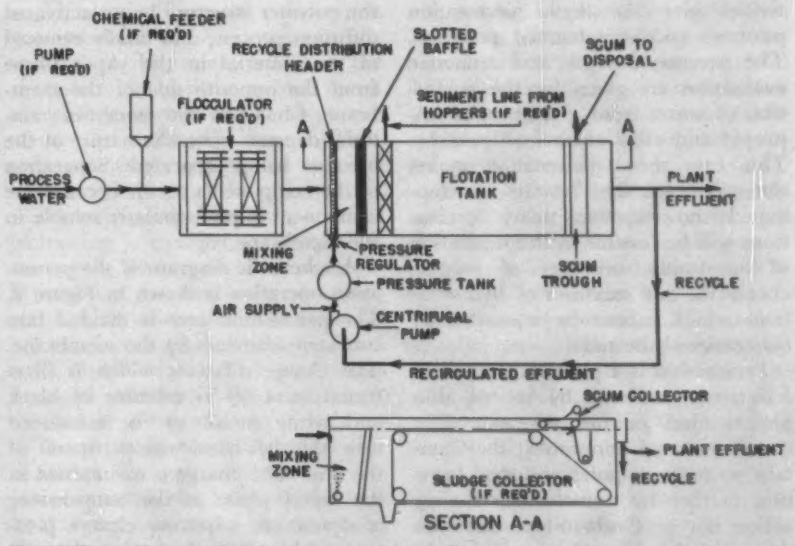


FIGURE 4—Shows a flotation system which utilizes recycle effluent to facilitate the introduction of air into the flotation system.

About the Author

William J. Katz is supervisor of the hydraulics laboratory in the research and development division of Chain Belt Co., Milwaukee. In this capacity he heads the research in industrial and domestic waste treatment. Katz received his B.S. degree in chemical engineering at the University of Illinois and his M.S. and Ph.D. degrees in chemical engineering from the University of Wisconsin. He remained on the staff at Wisconsin until he joined Chain Belt four years ago. Katz received the Harrison Prescott Eddy medal in 1955 from the Federation of Sewerage and Industrial Waste Association.

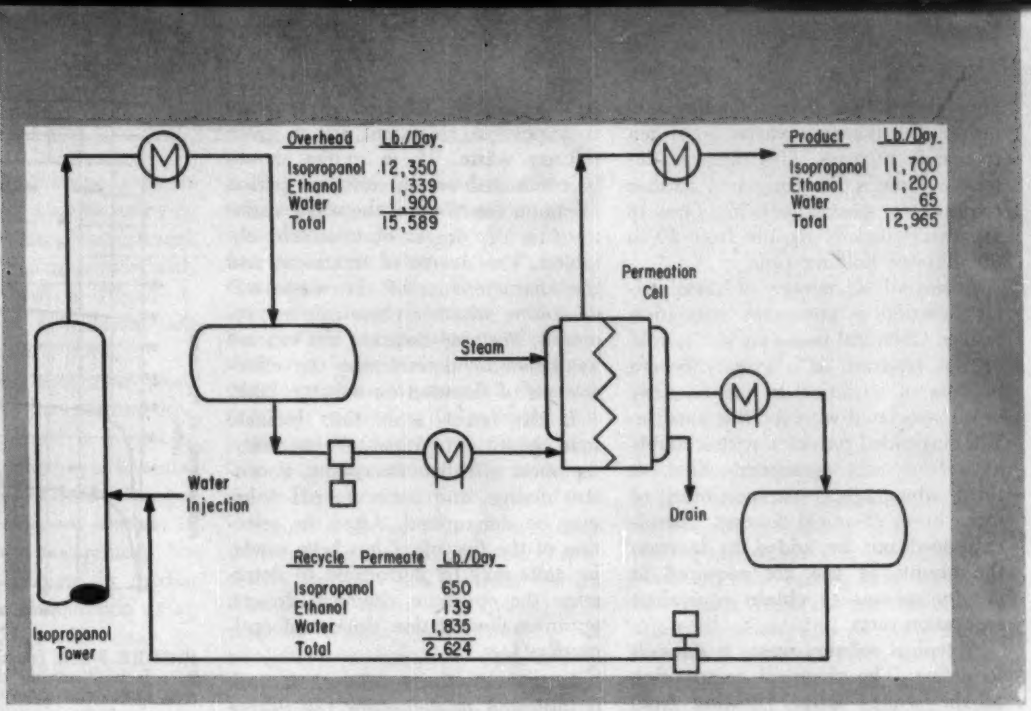


FIGURE 1—Investment and some operating costs for this new process are less than azeotropic distillation with hexane. Compare this method with your present way of making hard-to-do separations.

Now Separate by Membrane Permeation

This process splits components on the basis of their solubility in a polymer membrane. In some cases it is easier and cheaper than by more conventional methods.

Robert C. Binning and Frank E. James
American Oil Company, Texas City, Texas

RAPID RATES of permeation, simplicity of design, and excellent selectivities give the liquid permeation process good commercial potential. The process design and economic evaluation are given for the separation of water from a mixture of isopropyl and ethyl alcohol (Figure 1). This case shows permeation makes the split better than hexane azeotroping. It now appears many applications will be feasible in the separation of azeotropes, mixtures of organic chemicals, and mixtures of hydrocarbons which cannot be separated by conventional means.

Permeation is a physical method of separating mixtures by use of thin plastic films or membranes. The membranes are nonporous; they contain no holes or pores and they function neither by a molecular sieving action nor by Graham-type diffusion through holes. Instead permeation requires solubility of material in the polymer comprising the membrane, movement of the material through the polymer structure by an activated diffusion process, and finally removal of the material in the vapor phase from the opposite side of the membrane. Choice of the membrane material depends upon the nature of the mixture being separated. Separation of the components occurs because one component is preferentially soluble in the membrane.

A schematic diagram of the permeation operation is shown in Figure 2. The permeation unit is divided into two compartments by the membrane. The charge mixture, which is illustrated as a 50-50 mixture of black and white molecules, is introduced into the left-hand compartment of the unit. The charge is maintained in the liquid phase at the temperature of operation, requiring charge pressure to be atmospheric or whatever the vapor pressure of the mixture is at the operating temperature. The right-hand side is maintained at a lower pressure so that the permeate is vaporized.

As shown in the diagram, the white molecules preferentially pass through or permeate the membrane. In the example shown, the product or permeate contains about 80 percent white molecules. This is typical of many systems where a one-stage permeation unit separates an 80-90 percent pure material from a 50-50 mixture.

Permeation is particularly useful as a separation method whenever simple distillation is either of no benefit or requires extensive equipment in terms of number of plates. Just as differences in boiling point or vapor pressure are the criteria for estimating the difficulty of separation in distillation, solubility properties and molecular structure are the criteria in permeation. The membrane permeation

process is useful for separating wide varieties of liquid mixtures. Close boiling mixtures, azeotropic mixtures, and even wide boiling mixtures can be separated. Hydrocarbon mixtures such as petroleum fractions can be processed to recover aromatics, to separate hydrocarbon isomers, to improve octane number of gasoline boiling range fractions, and to otherwise refine or concentrate such mixtures.

It also may replace certain solvent extraction operations. Some of these costly separation techniques may be carried out much more cheaply by permeation. The simplicity of equipment needed for permeation is the primary reason for its favorable economic comparison with other separation methods. The major piece of equipment is, of course, the film holder. Means must be provided for supplying the heat of vaporization and this can usually be done by jacketing the film holder. In some cases, a moderately reduced pressure in the permeate zone may be required to remove the vapor phase permeate.

The important variables in either rate or selectivity are film composition, film thickness, temperature, and pressure. Both rate and selectivity are primarily controlled by the choice of film. The choice depends on the nature of the mixture, and experimental work is generally needed to guarantee a proper film selection. A typical film might resemble cellophane wrap on cigarettes in respect to thickness and toughness.

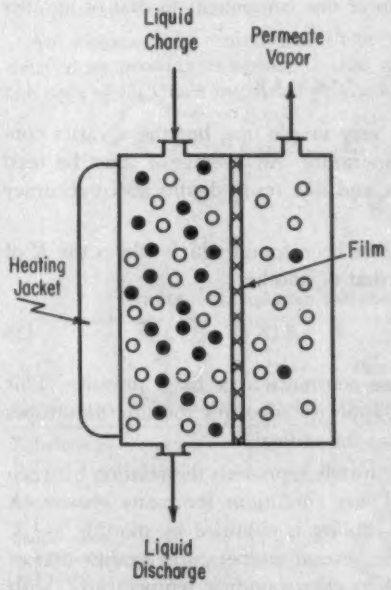


FIGURE 2—In a typical system, one stage will produce an 80-90 percent material from a 50-50 charge mixture.

TABLE 1—Cost Comparison for Isopropanol Drying Processes

	Membrane Permeation	Hexane Azetroping
Investment for New Equipment	$76,000	$100,000
Operating Costs, $/Year*		
1. Labor, ¼ Operator at $3/Hr	6,570	6,570
2. Supervision, 15% of Labor	990	990
3. Maintenace Labor, 2.5% of Investment	1,900	2,500
4. Labor Benefits, 20% of (1), (2), (3)	1,890	2,010
5. Maintenance Materials, 1.5% of Investment	1,140	1,500
6. Hexane Loss, $0.17/Gal.	.....	470
7. Membrane Replacement, $2/Film Unit	220	.....
8. Utilities	740	1,620
9. Gen. and Admin. Overhead, 50% of (1), (2), (3), (4) (5)	6,240	6,780
10. Property Taxes and Insurance, 1.5% of Investment	1,140	1,500
Annual Cost, $/Year	$20,830	$23,940
Unit Cost, ¢/Lb.	0.64	0.74
Capital Costs, $/Year		
Cost to pay out investment in 5 years with profit after income taxes plus depreciation***	$23,400	$30,800
Sum of Capital and Operating Costs		
Annual Cost, $/Year	44,230	54,740
Unit Cost, ¢/Lb.**	1.36	1.68

* Based on operating factor of 85%.
** Based on 10,470 lbs/SD of crude isopropanol feed (dry basis).
*** Depreciation rate at 10% per annum, income tax at 52%.

For an example, a process design for a commercial installation charging 15,600 pounds per day of a ternary azeotrope has been made. A simplified diagram of the process flow is shown in Figure 1. The application here illustrates the simplicity of the separation method and, as will be discussed later, definite economic advantage of permeation over the best alternate scheme.

Here a ternary azeotrope of isopropanol, ethanol, and water is an overhead product from a distillation tower. This stream, as produced, has little or no market value because of the water present therein. Mixed alcohols containing a maximum of 0.5 percent water are salable. Permeation equipment was proposed which would selectively remove a water-rich material from the ternary azeotrope and reduce the water content in the alcohols to 0.5 percent or less. As an alternate to permeation, a two-tower azeotropic distillation scheme was proposed using hexane for the entrainer.

The ternary overhead product after preheating is charged to the permeation cell. The water-rich permeate is returned to the water injection point of the tower therefore eliminating any loss of alcohols which permeate with the water. The ethanol-isopropanol mixture not passing through the film is sent to product storage.

The permeation cell has a film area of about 650 square feet. A steam jacket around the cell supplies the heat of vaporization for the permeate. The films are precut and mounted for support and to facilitate ease of placement in the cell. The cell with its auxiliary equipment would fit into a space about 8 feet long, 6 feet wide, and 6 feet high.

Of primary interest to operating personnel is the reliability or stability of the films and down time required for changing them. Certainly, operating with and handling these films which are only about 1/1,000 of an inch thick would appear to be good reason to doubt their practical application. Films have, however, been in use under a variety of conditions for several month's continuous operation with no failure. The films themselves are tough and will withstand abuse except for pricks by sharp or pointed objects. The membranes are supported to enable them to withstand the pressure difference during operation. Placing the films in the cell is comparable to positioning stiff paper in a filter press. In the particular design described above, a surge tank to hold 48 hours of charge was included. Actually, changing the films should be accomplished easily in a unit this size in one 8-hour shift.

Table 1 shows the comparative economics of the membrane permeation scheme and the alternate using azeotropic distillation with hexane. The estimated investment for azeotropic distillation equipment is 31 per cent greater than for the permeation equipment. Annual operating costs are also 15-16 percent greater for azeotropic distillation. Capital costs would, of course, be less for permeation because of the lower investment. The real difference between the two alternates is in the cost per pound of marketable alcohol—about 20 percent less for permeation. ##

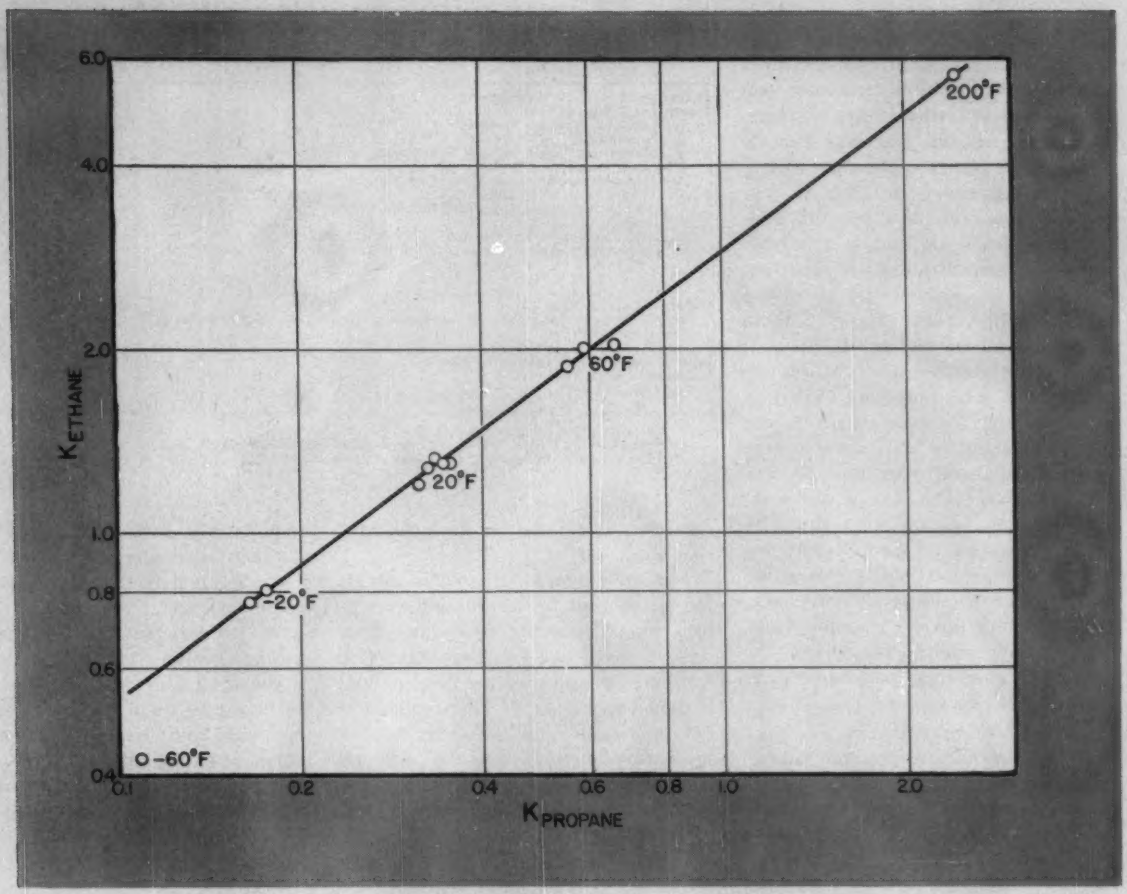


FIGURE 1—Representation of Equation (2) for ethane-propane system.

New Relative Volatility Method for Distillation Calculations

This new relation holds accurately for many systems at constant pressure even though the temperatures may vary several hundred degrees.

Francis W. Winn
Fractionation Research Incorporated
Alhambra, Calif.

THE USUAL METHOD of relating the vapor-liquid equilibrium K ratio of one component to that of another is by the equation

$$K = \alpha K' \qquad (1)$$

This equation is a very simple one, but the α varies considerably with temperature. An average α must be used for many problems, and as a result doubts about accuracy arise.

A new equation has been found which relates the K of one component to that of another:

$$K = \beta (K')^b \qquad (2)$$

where β and b are constants at a fixed pressure. This equation does not apply to mixtures forming azeotropes or at conditions near the critical.

The equation accurately represents the relation between isobaric K's at ordinary conditions for many systems. A simple test of applicability is obtained by plotting log K of one component at several temperatures against that of another component at corresponding temperatures, with pressure held constant. The relation holds if a straight line may be drawn. As an example, Figure 1 shows a plot

of log K ethane against log K propane from DePriesters' experimental data[2] at 200 psia. The N_2-CH_4 data of Cines, et al.[1] also are well represented by the equation except in the critical region.

The equation can be derived from the following type of vapor-pressure equation:

$$\log P = A + B/T \quad (3a)$$

$$\log P' = A' + B'/T \quad (3b)$$

On the assumption that Raoult's and Dalton's laws hold,

$$\log P/\pi + \log \pi - A = B/T \quad (4a)$$

$$\log P'/\pi + \log \pi - A' = B'/T \quad (4b)$$

Dividing (4a) by (4b) to eliminate temperature and substituting K for P/π gives.

$$\frac{\log K\pi - A}{\log K'\pi - A'} = \frac{B}{B'} = b \quad (5)$$

$$\text{from which } K = \beta (K')^b \quad (6)$$

$$\text{where } \beta = \pi^{b-1} 10^{A - bA'} \quad (7)$$

Although the constants of Equation (2) may be evaluated by means of vapor-pressure data, a more accurate representation is obtained by use of experimental K data or K correlations.

Minimum Theoretical Trays. Minimum trays are conventionally determined by tray-to-tray calculations, by stepping off stages on a McCabe-Thiele diagram, or by use of the Fenske equations.[3] The McCabe-Thiele method is accurate if large-scale plots are used but it requires the preparation of an x-y plot. The Fenske equations do not give reliable results if the relative volatility varies appreciably, as in the case of widely differing top and bottom tray temperatures.

Because Equation (2) does accurately represent K data over the temperature ranges ordinarily encountered in commercial practice, its use will yield an accurate value of minimum theoretical trays.

An equation for minimum theoretical trays can be derived by procedures similar to that used by Fenske. For the case of all vapor overhead product,

$$\frac{y_D}{x_B} = K_B K_1 K_2 \ldots K_n K_D \quad (8)$$

$$\frac{y'_B}{x'_B} = K'_B K'_1 K'_2 \ldots K'_n K'_D \quad (9)$$

TABLE 1—Alkylation Deisobutanizer

Component	Feed, moles	Overhead, moles	Bottoms, moles	Equilibrium K's	
				Top tray	Reboiler
Ethylene	1	1	....	....	....
Ethane	2	2	....	....	....
Propane	48	48	....	....	....
Isobutane	863	848	15	0.94	3.55
n-Butane	132	71	61	0.70	3.00
Isopentane	33	....	33	....	....
n-Pentane	5	....	5	....	....
Alkylate	277	....	277	....	....
	1361	970	391	....	....

Dividing each side of Equation (8) by the b power of Equation (9), and combining with Equation (2), one obtains

$$\beta_{n+2} = \left(\frac{y_D}{x_B}\right)\left(\frac{x'_B}{y'_D}\right)^b \quad \text{for vapor overhead product} \quad (10)$$

Similarly,

$$\beta_{n+1} = \left(\frac{x_D}{x_B}\right)\left(\frac{x'_B}{x'_D}\right)^b \quad \text{for liquid overhead product} \quad (11)$$

The relation here can be used conveniently to store K data in both digital and analog computers . . . Potential applications of the relation include the calculation of minimum reflux and the number of equilibrium stages at finite reflux ratios.

Equations (10) and (11) may also be written in terms of product rates:

$$\beta_{n+2} = \left(\frac{V_D}{W}\right)\left(\frac{W'}{V'_D}\right)^b \left(\frac{B}{D}\right)^{1-b} \quad \text{for vapor overhead product} \quad (12)$$

$$\beta_{n+1} = \left(\frac{L_D}{W}\right)\left(\frac{W'}{L'_D}\right)^b \left(\frac{B}{D}\right)^{1-b} \quad \text{for liquid overhead product} \quad (13)$$

For the case where the overhead product is part liquid and part vapor, either Equation (10) or Equation (11) may be used, or in terms of product rates

$$\beta_{n+1} = \left(\frac{d}{w}\right)\left(\frac{w'}{d'}\right)^b \left(\frac{W}{K_D V_D + L_D}\right)\left(\frac{K' + L_D}{W'}\right)^b \quad (14)$$

Equation (14) applies for the general case. It can be reduced to Equations (10) to (13).

Distribution of Other Than Key Components

The foregoing equations apply to any pair of components in a multicomponent system. The key components having been used to establish the number of trays, the distribution of other components at total reflux is fixed.

Example: The minimum number of trays necessary to deisobutanize the effluent from an alkylation reactor will be calculated. The feed, products, and vapor-liquid equilibrium constants of the key components at conditions of temperature and pressure corresponding to the top tray and reboiler are shown in Table 1. The tower has a total condenser.

The constants β and b are evaluated using Equation (6) as follows:

$$0.94 = \beta (0.70)^b$$

$$3.55 = \beta (3.00)^b$$

$$3.78 = (4.29)^b$$

$$b = 0.913$$

$$\beta = 1.301$$

By use of Equation (13) the minimum number of theoretical stages is calculated as follows:

$$(1.301)^{n+1} = (848/15)\ (61/71)^{0.913}\ (391/970)^{0.087}$$

$$(1.301)^{n+1} = 45.5$$

$$n + 1 = 14.5$$

This is exactly the number of stages obtained by tray-to-tray calculations with the K correlation of Winn.[4] The minimum number of stages by the Fenske equation, with a geometric average α of 1.261, is 16.8. The Fenske equation gives an answer which is too high by 2.3 stages, or 16 percent.

Other Applications

Computers: The relation also can be used as a convenient means for storage of K data in digital and analog computers. In this application the following, more versatile, form of Equation (2) may be used:

$$K_{n1} = \beta\,[f(T)]^b \qquad (15)$$

$$f(T) = K'_{n1} \qquad (16)$$

where β and b are functions of component identities and pressure $\pi 1$ and $\pi 2$. This equation also applies to many systems except in the critical region. A test of applicability is obtained by plotting at corresponding temperatures log K of any component at constant pressure against log K of a base component at another pressure. Figure 2 shows a plot of the nitrogen-methane data of Cines, et al.,[1] on this basis. It will be noted that a straight-line relation is obtained even though this system is far from being ideal.

Finite Reflux Ratios: Potential applications of the relation include the calculation of minimum reflux and the number of equilibrium stages at finite reflux ratios.

This paper was presented at the Seattle, Wash., meeting of the American Institute of Chemical Engineers, June, 1957.

NOTATION

A, B = constants in vapor-pressure equation
b = exponent in equation (2)
d = moles of a component in overhead product
D = total moles of overhead product
n = minimum number of equilibrium trays in tower
$K = y/x$ = vapor-liquid equilibrium ratio for a component
L = moles of a component in liquid phase
P = vapor pressure, psia
T = absolute temperature, °R
V = moles of a component in vapor phase
w = moles of a component in bottoms product
W = total moles of bottom product
x = mole fraction of a component in liquid phase
y = mole fraction of a component in vapor phase
α = relative volatility
β = constant in Equation (2)
π = total presure, psia
L = total moles in liquid phase
V = total moles in vapor phase

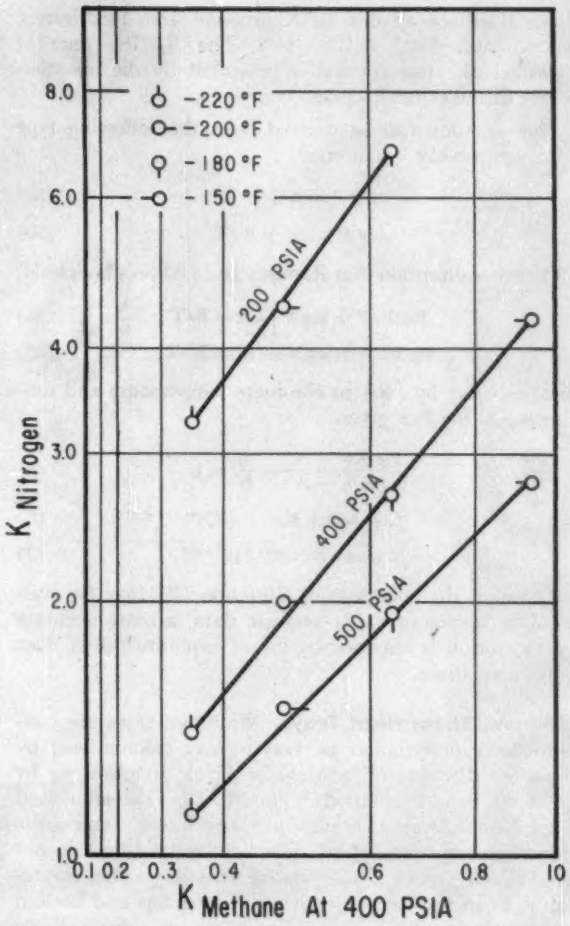


FIGURE 2—Representation of Equation (15) for the nitrogen-methane system.

SUBSCRIPTS AND SUPERSCRIPTS

D = distillate
B = bottoms
1, 2 . . . = tray number
(′) heavy key component

LITERATURE CITED

[1] M. R. Cines, J. T. Roach, R. J. Hogan and C. H. Roland, *Chem. Eng. Prog.*, No. 6, 49, 1 (1953).
[2] C. L. DePriester, *ibid.*, No. 7, 49, 1 (1953).
[3] M. R. Fenske, *Ind. Eng. Chem.*, 24, 482 (1932).
[4] F. W. Winn, Petroleum Refiner, 33, 482, 131 (1952).

About the Author

Francis W. Winn is technical director in charge of research for Fractionation Research Inc., Alhambra, Calif. A chemical engineering graduate from the University of Oklahoma, he joined the company in 1951, following an assignment as assistant chief engineer with Catalytic Construction Corp. He also has been associated with a number of major oil companies and once served with the Petroleum Administration for War. In past years Winn has contributed many excellent articles to Petroleum Refiner.

FIGURE 1—Fractionation unit at Sweeny: Three columns now operate better with analytical controls.

What's New in Fractionator Control

Here's how Phillips designed analytical controls for a depropanizer, debutanizer and deisobutanizer.

T. C. Wherry and D. E. Berger
Phillips Petroleum Company, Bartlesville, Okla.

THREE MAJOR fractionating columns are now automatically controlled by analytical instrumentation to a level of performance unobtainable by conventional instrumentation. In operation since October, 1956, the columns are part of the natural gas liquids fractionation unit at Phillips Petroleum Company's Sweeny refinery.

As shown in Figure 1, the major pieces of equipment are the three fractionating columns, a 50-plate depropanizer, a 100-plate (2-section) deisobutanizer and a 50-plate debutanizer. Each fractionating column is 13 feet in diameter by 120 feet high.

The process flow sequence is shown in Figure 2 with stream compositions and product yields included. The design and the operational control of the unit was predicated on very high recoveries of isobutane from the propane and normal butane streams, and

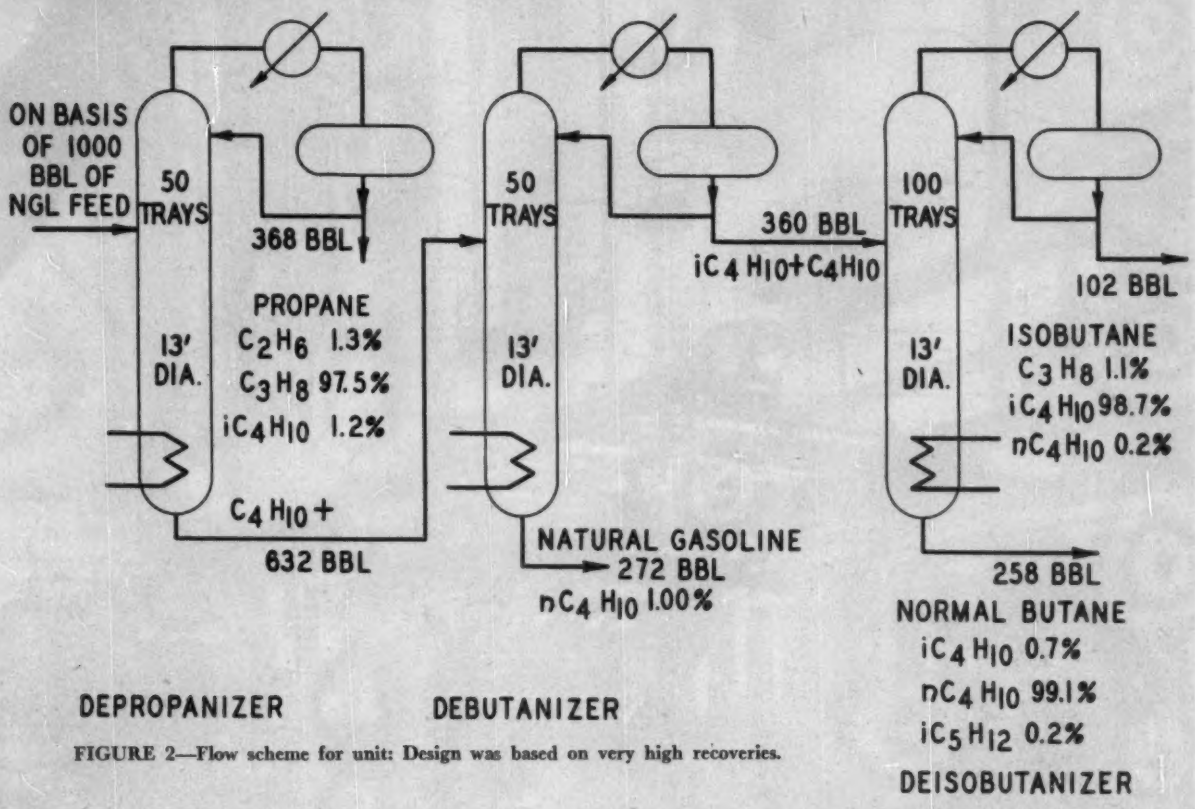


FIGURE 2—Flow scheme for unit: Design was based on very high recoveries.

of isopentane and the higher boiling natural gasoline components from the normal butane stream. Therefore, automatic control was based on isobutane measurement in the depropanizer and deisobutanizer. Similarly isopentane plus normal pentane was selected as the control component in the debutanizer.

To provide the adequate instrumental control desired by the process designers, the following subjects were considered simultaneously: (1) methods of measurement of these components in their mixtures, (2) sampling the process at points where these component measurements are especially meaningful and are suitable for automatic control, and (3) automatic process control systems for the columns which would provide stable concentration control with rapid correction of concentration deviation due to transient process disturbances (generally introduced by the feed). Needless to say, all these diverse but interrelated subjects required many compromises before final recommendations were made.

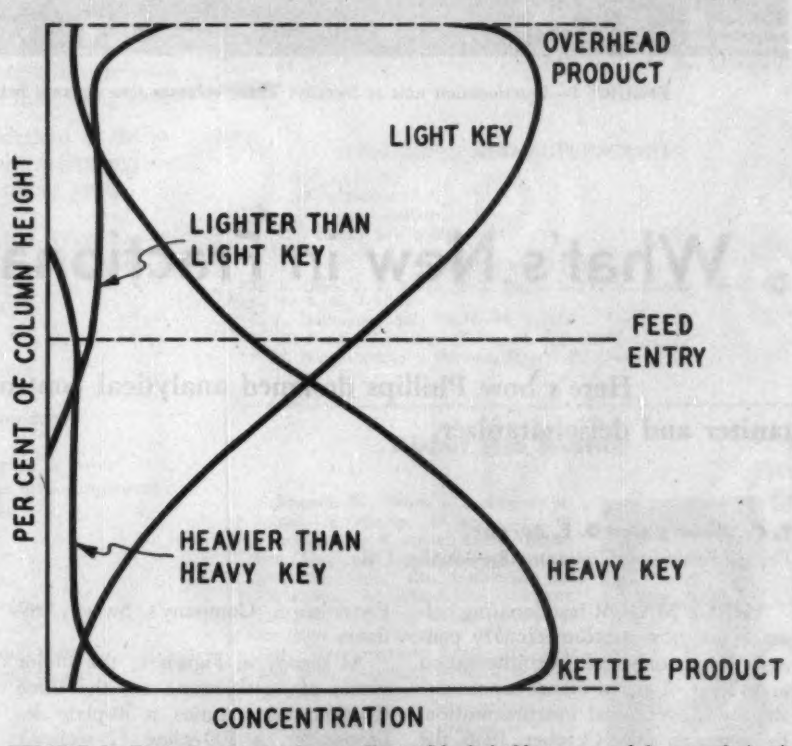


FIGURE 3—Typical concentration gradients: It's desirable to control from analysis of the light key component below the column feed entry or of the heavy key component above the feed entry.

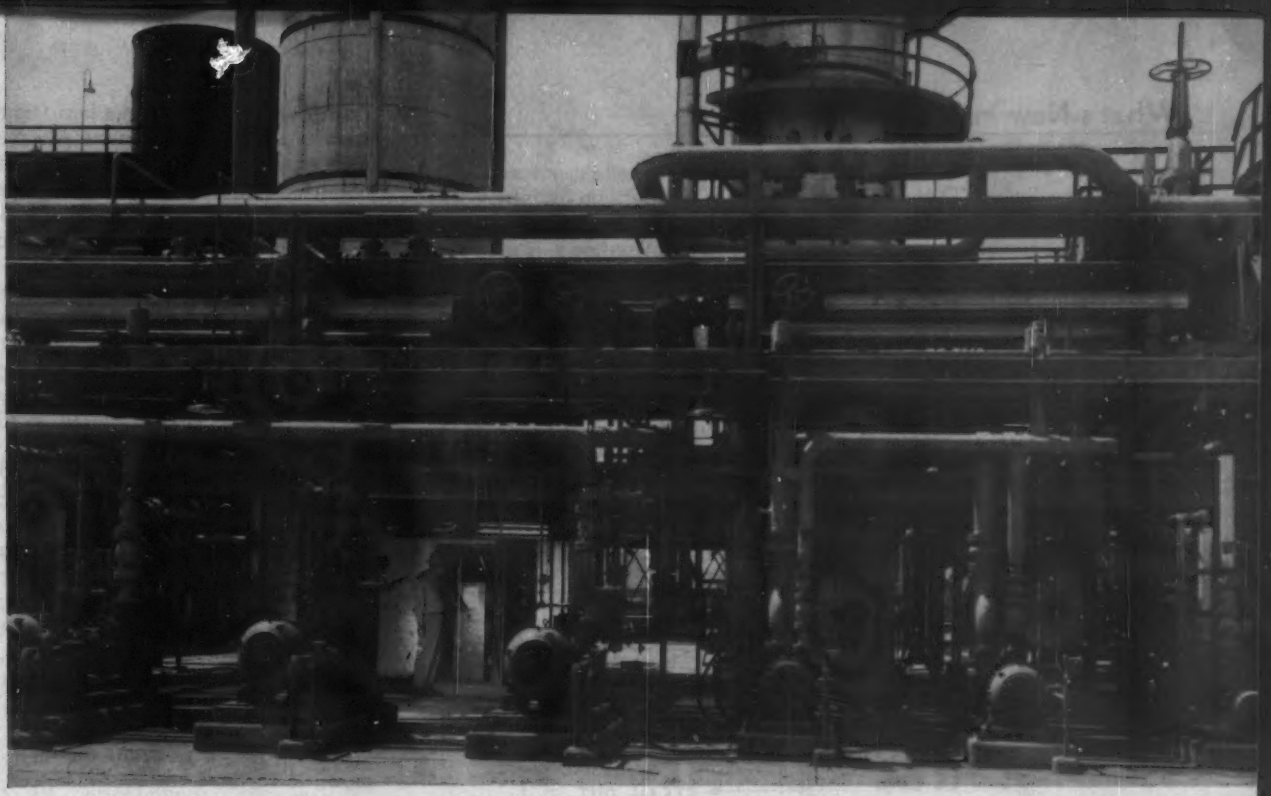


FIGURE 4—Process refractometer at the debutanizer column.

Several methods are available for hydrocarbon analysis. The choice was simplified since, in the authors' opinions, only infrared analyzers and differential refractometers had been developed to a sufficiently reliable and explosion-proofed stage. It is well to note, however, that at the time of these decisions, gas chromatography for automatic process control was merely a promising gleam on the horizon.

Since the samples to be analyzed from each of the three columns were multicomponent mixtures, the analytical instruments had to be quite specific to the control components. In the depropanizer, where isobutane was to be measured in the presence of ethane, propane, and normal butane, and in the deisobutanizer where isobutane was to be measured in the presence of normal butane and isopentane, it was obvious that infrared analysis was to be preferred. However, in the debutanizer the aim was to measure the combined isopentane plus normal pentane concentrations in the presence of isobutane and normal butane to effectively control this $C_4 - C_5$ separation. Here, some investigation revealed that measurement of the refractive index of the sample in the gaseous state would give in effect a molecular weight analysis and would not differentiate among the isomers.* Uniquely, the nonspecificity of refractive index was what was desired.

In previous work on fractionator control,[3a, 4a, 14, 20] Phillips established the desirability of control from analysis of the light key component below the column feed entry or of the heavy key component above the feed entry. Figure 3 presents typical concentration gradients. Also established were the pro and con factors concerned with location of sampling point.

The factors favored by sampling at, or very near, the column terminals are (1) freedom from ambiguity in the correlation of sample composition with terminal composition, and (2) improved control loop behavior due to reduction of transport lag (dead time) and of the time constants (lags) describing the sampling point's compositional behavior. This assumes that the manipulation for control is applied at the same terminal (steam or reflux as the manipulated variable). The factors favored by sampling nearer the feed entry are (1) improved terminal composition behavior due to earlier recognition of composition transients as they proceed from the feed entry toward the column terminals, and (2) less stringent analytical requirements due to (a) analyzing the control component at a higher concentration and over a wider range, (b) simplifying the multicomponent mixture since non-key components tend to exhibit constant composition zones in the column. These latter points often make "impossible" analyses possible.

On the basis of the above discussion, using machine calculated concentration gradients and the fractionator dynamics knowledge available to the authors, the following compromises and decisions were made. For depropanizer control, an infrared analyzer was sensitized for measurement of 0 to 20 mole percent isobutane in the presence of ethane, propane and normal butane, with the sample being drawn from the vapor phase of tray nine (from the column top). For debutanizer control, a process refractometer was modified for gas phase analysis at 28 p.s.i.a. cell pressure. The reference gas used is normal butane, pure grade, at the same pressure. The sample is drawn from the vapor phase of tray nine (from top). At this point the concentration of propane is nor-

* U. S. Patent 2,771,149 and patents applied for.

mally low and constant, therefore essentially negligible. Thereby, the instrument is calibrated in terms of 0 to 20 mole percent pentanes in butanes. For deisobutanizer control, an infrared analyzer was sensitized for measurement of 0 to 30 mole percent isobutane in normal butane and isopentane, with the sample being drawn from the vapor phase of tray 84 (16 trays from the column reboiler).

These three analytical instruments were designed into the plant. Figure 4 is a photograph of the process refractometer installation at the debutanizer column. Sampling system design was similar in all three cases, requiring vaporizer-regulators, steam traced sample lines and vents as shown in Figure 5. Particular efforts were made to reduce sampling delay since it increases measurement dead time and seriously depreciates control system performance, often to the point of instability. Sample transport times of about one minute were achieved.

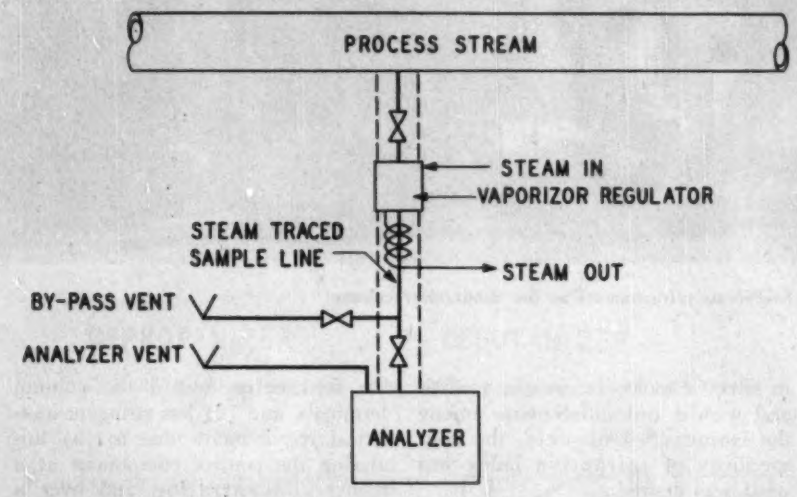


FIGURE 5—System for clean liquid sample requires vaporizer-regulators, steam traced sample lines and vents.

Numerous fractionation column control systems have been proposed, designed and used. Published test results are quite scarce.[4a, 5, 11, 14, 18, 20] While most column control systems appear to include many small control loops, careful analysis of cause and effect will reveal that normally only one "major" (composition controlling) loop is present. Sophistication of control systems may lead to the use of several major loops,[1a] which are at least theoretically possible. This measurement, whether specific (component composition by infrared, etc.) or nonspecific (temperature/pressure, refractive index, etc.), is used to manipulate a control valve on one of the flowing streams of material or energy. No matter which stream is manipulated, it will be seen that the effects of this control action appear in either the feed stream, reflux stream or the reboiler heat input. Only these streams are capable of influencing the balance of material versus energy, thereby forcing a certain composition to exist at a certain point in the column (after the transients die out). With this point established, elementary reasoning will lead one to the conclusion that direct manipulation of feed, steam or reflux flow from the composition sensor will result in the least delay in application of control action as well as the avoidance of spurious control signals (noise) present in liquid level and other control installations.

Within the author's experience, the majority of the columns have no freedom of manipulation of feed rate, let alone feed composition. One outstanding example of effective feed manipulation is described by Campbell and Godin.[3a] Therefore the choice of major manipulated variable is usually between steam and reflux. In the previous papers, where reflux[4a] and extractive distillation solvent[14] flow rates were manipulated, these major loops possessed considerable dead time as well as large lags (time constants). Recent test work on the composition response to heat input manipulation has revealed that the dead time is about half that encountered during reflux manipulation while the exponential lags remain substantially the same. In considering the rate of propagation of energy through the column, it is readily apparent that vapor passes through the column more rapidly than does liquid[14] (probably due to pressure effects as well as to the relative weights of each phase held up). Therefore the L/V in all portions of the column except the top few plates, is influenced with less delay by steam manipulation than by reflux manipulation. If the above combination of plant test experience and reasoning is accepted, then it must be concluded that, in most cases, manipulation of reboiler heat input by the composition controller is by far the most effective control system.

Therefore, a control system as shown in Figure 6 was recommended, designed, constructed, and put into operation on each column. As can be seen, extensive use was made of cascaded controls. While this tends to increase instrumentation costs and complexity, it does lead to much improved control "smoothness," and, particularly in the analysis control loop allows independent exercise of control over the secondary variable without becoming involved with the dead time and the large time constants of the primary loop.

Control System Performance. To adequately describe the plant performance of a control system appears to us to be a quite difficult task. At the present state of available knowledge, it is impossible to estimate what ideal performance might be. Neither can the behavior of these highly nonlinear systems be expressed in conventional mathematical terms. It is possible, however, to compare the performances of alternative control systems on the basis of closed loop responses judging that the one exhibiting the least dead time, the smallest time constants, the best correlation between terminal and sample compositions and/or the "smoothest" terminal composition record is the best. If it were possible to express control system performance in economic terms, no doubt the task would be simplified.

The authors note with pleasure the

plant work performed by Aikman[11] and by Hoyt, et al.[18, 19] and wish to encourage futher publication of the characteristics of control system, preferably evaluations of alternative systems. The authors are proceeding with mathematical analysis of control systems and hope to publish some results soon.

Since analytical instruments in general are not as reliable as pressure gages or, for that matter, temperature controllers, to discuss the effectiveness of a control system where an analysis is the primary measurement, one must at least consider the factors which occasionally take the analytical instrument from control service and force dependence back onto temperature or other control methods and onto laboratory analysis.

As the result of careful installation and maintenance of these instruments and their sampling systems, this downtime can be reduced to a very few percent of plant operation time. Due to the control options usually available to the operator in charge of a unit, the percent of on-control time is not as high. (Considerable benefit is still gained when the operator uses the analysis record for his guidance in setting temperature and/or flow control points.) A serious malfunction of any portion of this automatic control system can severely upset operations for a period of hours, so one tends to be very conservative in its use. In a number of instances we have found that a narrow range of cascaded control is highly desirable (i.e., limiting the band within which the primary controller can manipulate the set point of the secondary controller to 25 percent of full scale or less). This permits small secondary set point changes to be made and prevents the too large changes capable of process upset. Manufacturers of miniaturized recording-controlling instruments for our industry should reincorporate this desirable feature in their present products.

Results to date have shown that these analytical control systems have brought about excellent composition control of the product streams, and this performance is considerably superior to that obtainable by the best temperature control systems we know how to construct. No story is complete without mention of shortcomings, however. In the depropanizer and deisobutanizer control systems, where the measurement is highly specific,

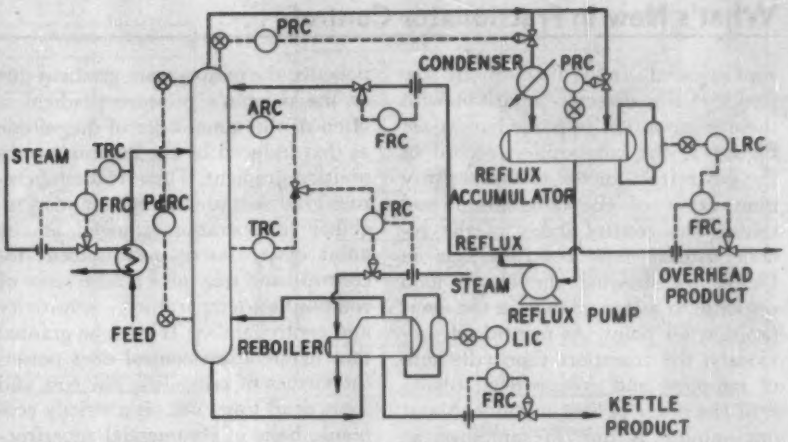


FIGURE 6—Typical column control system: Cascade controls lead to improved control smoothness.

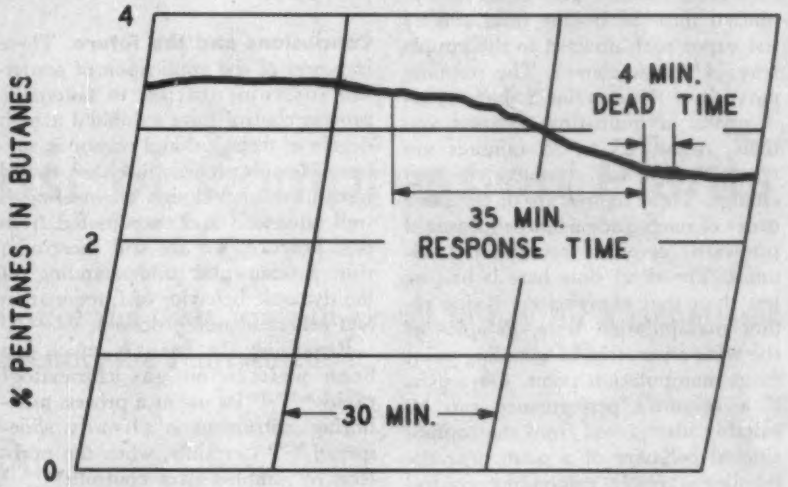


FIGURE 7—Response to composition set point step change: Transport time is about four minutes.

the data which have been collected shows that the correlation between sample composition and terminal composition is about what might be expected if one takes into account changes in feed composition.[4a] That is, terminal composition is closely (±½ percent or less of measured component) but not exactly controlled. If, when interpreting this data, one accepts a slightly lowered confidence level, a figure of ±¼ percent is realistic. In the debutanizer control system this same degree of correlation exists if the propane concentration is low and constant at the sample point. Some severe propane transients (a few percent in feed) have occurred because of transient behavior of the depropanizer. Due to the characteristics of gas refractive index, propane reduces the sample's refractive index and is interpreted as reduced pentanes concentration. These have resulted in ambiguous control for short periods of time. It is only fair to point out that if temperature control of comparable sensitivity were used, the ambiguity would be worse. Nevertheless, the combination of good sample points, specific analyses and relatively fast control system does provide stable and generally unambiguous correction of deviations in the true quality specification, chemical composition of product. In the future when continuous optimization of plant performance is attempted via computers, analytical instruments will be making the critical primary measurements.

The ease with which it is possible to determine the responsiveness and stability of our control systems by the introduction of step transients either in one element of the closed loop or elsewhere in the process (noting the closed loop behavior), has led the authors to publish some of this un-

sophisticated information in the past.[4a, 14] For direct comparison with these composition response curves, see Figure 7, the composition record of the gas refractometer (sampling tray nine vapor of the debutanizer and setting the control index of the reboiler steam flow controller, as in Figure 6) showing the closed loop response to a step change in the composition set point. As mentioned previously, the transport time (the sum of sampling and process dead times) is of the order of four minutes. About one minute is due to sampling, so three minutes represents process dead time from reboiler heat input manipulation into the boiling fluid and by the vapor path upward to the sample tray (41 trays above). The response curve is of the familiar S shape characteristic of multi-time-constant systems. About 25 to 35 minutes are required to nearly complete the step change. These figures are of the same order of magnitude as those measured previously or other fractionating columns. The dead time here is half or less than that experienced during reflux manipulation tests, in spite of the wide separation of sampling point from manipulation point. Obviously, if a column's performance can be suitably interpreted from the compositional behavior of a point near the reboiler a faster responding control system may be constructed.

Probably the greatest concentration of fractionating column control system "inertia" exists in the large and poorly-mixed reflux accumulator. Reductions in the size of and in operating level in the accumulator will benefit control system response and consequently fractionator economic performance. It has also been observed in test work, that selection of point of temperature-measurement-for-control-purposes is often based on the maximum slope of the temperature gradient rather than upon the composition principles discussed previously. It should be pointed out that a temperature measurement infers a composition measurement exactly like an analytical instrument but to a lesser degree of specificity. In addition, the temperature is responsive to column pressure transients at the measuring point. It has been noted that in columns separating essentially binary mixtures of close-boiling components, the temperature gradient due to the column's pressure gradient is often of the same order of magnitude as that induced by the column's composition gradient. These two temperature gradients are of course added together in operation (hinged at the point of pressure measurement for control) and may give a false sense of composition-temperature sensitivity and controllability. It must be granted that temperature control does possess the virtues of reliability, low cost and short dead time, but on a strictly economic basis in commercial superfractionation, analytical control is to be preferred.

Conclusions and the future. These instances of the application of analytical instrumentation to automatic process control have exhibited a high degree of technical and economic success. Though process, mechanical and instrumentation design engineering is well advanced and coordinated from past practice, we are still short of a true fundamental understanding of the dynamic behavior of fractionation and others of our processes.

Regarding the future, much has been written on gas chromatography.[6, 7, 9, 10] Its use as a process monitoring instrument is already widespread.[7a, 10] Certainly, when the problems of sampled data control[1, 7b, 10, 12] and high speed chromatographic analyzers are worked out, there will be considerable automatic control activity. Very likely, a portion of this control work will be based on the multicomponent analysis, possibly through the medium of operating guide computation. The disclosure of this work through patent activity and through publication will indeed be an interesting story.

ACKNOWLEDGMENT

This article describes control system work performed by a number of Refining and Research and Development department personnel and contains technical know-how developed jointly by Refining, Natural Gasoline and Research and Development departments and Phillips Chemical Co. Appreciation is expressed to Phillips Petroleum Co. for permission to publish this article. Original presentation was before The Texas A&M Symposium on Instrumentation for the Process Industries, Jan. 22-24, 1958, College Station, Texas.

LITERATURE CITED

[1] Control Engineering, 3, No. 9, (1956). See pages 108 and 120. Also Control Engineering Manual, Ledgerwood, McGraw-Hill, 1957.
[1a] Ibid, page 112.
[2] Control Engineering, 4, No. 9 (1957). See pages 144, 148, 197.
[3] Industrial and Engineering Chemistry, 46, No. 7 (1954). See pages 1387, 1393.
[3a] Ibid, page 1413.
[4] Industrial and Engineering Chemistry, 48, No. 6 (1956). See pages 1008, 1020, 1031, 1035, 1042, 1047, 1064, 1069, 1074.
[4a] Ibid, page 1027.
[5] Plant and Process Dynamic Characteristics, Butterworths Scientific Publications, London, 1957, Academic Press, Inc., New York, 1957. See pages 29, 56, 73, 145, 170.
[6] Proceedings of Texas A&M Symposia on Instrumentation for the Process Industries, 1950-1957.
[7] Proceedings of Instrument Society of America National Meetings 1950-1957.
[7a] Ibid, 1957, B. W. Thomas.
[7b] Ibid, 1956, G. F. Franklin.
[8] Proceedings of ISA 1957 National Conference on Instrumental Methods of Analysis, Chicago.
[9] Proceedings of ISA Ninth (1957) Symposium on Process Fluid Analyzers, Newark, New Jersey.
[10] Proceedings of 1957 ISA International Symposium on Gas Chromatography, East Lansing, Michigan.
[11] Aikman, A. R., ISA Journal, 3, No. 10, 412 (1956).
[12] Aikman, A. R., ISA Journal, 4, No. 9, 363 (1957).
[13] Batke, T. L., Franks, R. G., James, E. W., ISA Journal, 4, No. 1, 14 (1957). Also Proceedings of ISA (1956), Part 1.
[14] Berger, D. E., Campbell, G. G., Chem. Eng. Prog., 51, No. 8, 348 (1955). Also Proceedings of ISA (1955), Part 3.
[15] Cowley, P.E.A., Proceedings of ISA (1956), Part 1. Also ASME-IRD paper 56-IRD-20.
[16] Hainsworth, B. D., Tivy, V. V., Paynter, H. M., ISA Journal, 4, No. 6, 230 (1957).
[17] Hollander, L., ISA Journal, 4, No. 5, 185, 1957.
[18] Hoyt, P. R., Stanton, B. D., Instruments, 26, No. 8, 1180 (1953). Also Pet. Refiner, 32, No. 10, 115 (1953).
[19] Hoyt, P. R., Stanton, B. D., Union, D. C., Mech. Eng., 79, No. 6, 586 (1957). Two abstracts of ASME-IRD Papers No. 57-IRD-15 and 57-IRD-16.
[20] Larrison, O. D., Purl, F. W., Harris, H. R., Petroleum Processing, 10, No. 11, 1750 (1955).
[21] Moore, H. F., Mech. Engr., 79, No. 10, 966 (1957), abstract of paper 57-ASME-EIC-1. Also Control Engineering, 4, No. 3, 23, 26 (1957).
[22] Mraz, D. M., Sanders, C. W., ISA Journal 3, No. 11, 459 (1956).
[23] Round Table Discussions on Process Control, Chem. Eng. Prog., 51, No. 8, 343 (1955) and Ibid., 53, No. 5, 209 (1957).
[24] Williams, T. J. et al., Chem. Eng. Prog., 53, No. 5, 220 (1957), also Pet. Refiner, 35, No. 4, 211 (1956) et seq. "Automation Today" series, also Reference (4), page 1008.

About the Authors

Wherry

Berger

Thomas C. Wherry is a supervisor in the special instrument section of the Instrument and Equipment division, Chemical Engineering department, Phillips Petroleum Co. He received B.S. degrees in both chemical and electrical engineering from Kansas State College in 1938. After joining Phillips in 1938, Wherry worked in the Production and Research departments.

D. E. Berger is a project planning engineer for Phillips Petroleum Co. He plans projects for instrument application and development, plant control and equipment development. Employed in Phillips' Research and Development department since 1941, Berger has a B.S. degree in chemical engineering from Michigan State University.

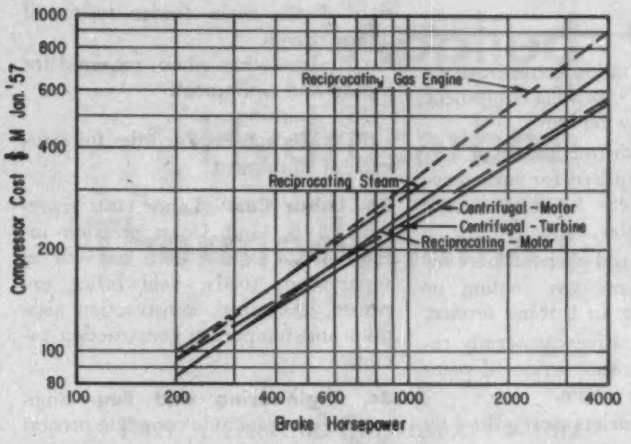


FIGURE 1—The cost of a completely installed compressor plant depends on the type of drive. Table 1 lists items which are included.

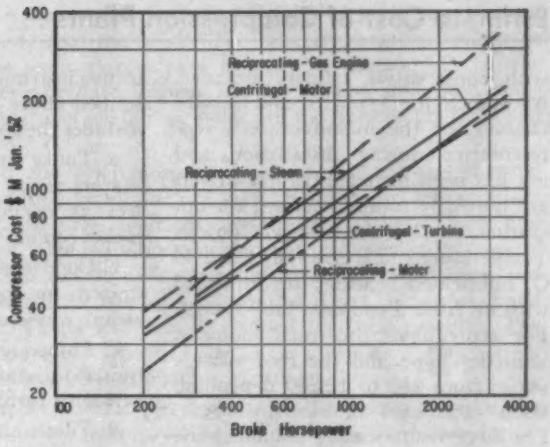


FIGURE 2—Compressor cost includes drive, gear mounting, base plate and normal auxiliary equipment.

Estimate Cost of Compression Plants

Here is a breakdown of the costs you can expect to pay for a compressor station. Several kinds of compressors are represented.

I. Bromberg
Foster Wheeler Corp.
New York, N. Y.

IN ORDER to provide a basis for evaluation of costs of compression plants of different types and capacities, an attempt is made here to analyze such plants based upon recent cost records and estimates. These compression units represent varied services in chemical plant and refinery design as well as varied specifications due to customer request and location.

In the tabulation of costs and the actual plotting of data, the basic data were adjusted in order to equate specifications and to average the requirements of the different services. Estimates and jobs of the past eight years have been brought up to date by means of appropriate material and labor indexes. It is intended that the resulting data should represent comparative tabulations of cost of units in January 1957 dollars conservatively designed in accordance with good petroleum refinery practice.

No aspects, other than initial costs, will be involved in the following inquiry. Process or mechanical reasons alone, may dictate the type of compression units. However, if choice exists, these tabulations are intended to indicate differences in installed costs.

Cost Data. Types of compression considered here are (A) motor driven centrifugal, (B) turbine driven centrifugal, (C) motor driven reciprocating, (D) steam driven reciprocating and (E) gas engine reciprocating. Although the company has designed and installed several gas turbine installations, cost data have yet to be adjusted and summarized. Table 1 indicates cost in thousands of dollars of component parts of the installed plant.

Usual process services represented by these units are cat cracker gas, cat reformer recycle gas, air, propane refrigeration and nitrogen.

Scope of Costs. The cost of a completely installed compression plant as shown in Figure 1 is represented herewith as the summation of material cost (3a), labor cost (3b) and contractor's engineering cost and fee (3c). Included in the material cost (3a) is the item of process equipment cost (2). Compressor cost (1) is included in process equipment cost (2). The following considerations are involved in our study including some idea of the compressor specification:

1. Compressor—Compressor costs shown in Figure 2 include the driver as well as gear mounted on a combined base plate with auxiliary equipment such as lube oil system, strainers, oil reservoir and control and pro-

with conservative refinery practice. Allowance for freight and service charges for the manufacturer's representative during installation and test has been included. Motor drivers are normally totally enclosed for operation on 3-phase 60-cycle power. Temperature rise is generally rated 40 C. Lubricated bearings are furnished with oil from a common lube system. For centrifugals the usual motor is induction type and the feed voltage varies from 440 to 12,200 depending upon economics of electrical gear. For large reciprocating machines the motors used are open synchronous type. Totally enclosed motors may cost as much as 100 percent more than open type machines, which may add up to 30 percent to the cost of compressor and driver. Turbine drivers are generally for 250-500 psig steam service, exhausting at about 4 in. hg. Steam driven reciprocating engines are designed for smiliar inlet steam service, generally exhausting to 15 psig. Gas engine driven machines are integral frame units including cost of starting air compressor system.

2. Process Equipment Cost—Besides the compressor and driver as detective instrumentation commensurate scribed above (1), process equipment includes the following items:

a. Tanks and drums including separators as are required for such services as condensate knockout and jacket cooling water, etc.

b. Condensers and coolers where required for process gas cooling or steam condensing in turbine service.

c. Pumps and drivers generally required for condensate service if compressor is turbine driven.

d. Filters and driers as required by process consideration.

e. Fabricated pulsation bottles where required for reciprocating equipment.

3a. Material Cost—Other items of material cost include:

(1). Foundations and paving for equipment, structure and building.

(2). Compressor and substation buildings allocated to individual machines.

(3). Piping and instrumentation within battery limits of the compression plant.

(4). Electrical lighting as well as the actual switch gear and a proration of the main feeder system if motor driven.

(5). Insulation where required for piping and equipment.

(6). Painting.

(7). Mechanical Facilities for servicing of equipment.

3b. Labor Cost—Labor costs represent U. S. Gulf Coast erection including all payroll costs as well as supervision, tools, field office expenses, insurance, construction supplies and temporary construction facilities.

3c. Engineering and Fee—Engineering costs include complete process design, project engineering, design and drafting services, purchasing, expediting, reproductions, communications and miscellaneous expenses of home office personnel. A nominal fee for contractor's general overhead and profit has been included.

4. Selling Price—(Figure 2)—The price of a turnkey compression installation is the summation of Material Cost (3a), Labor Cost (3b), and Engineering and Fee (3c).

5. Cost Per Horsepower—For rough estimating purposes costs per brake horsepower have been calculated.

6. Process Equipment Factor—When it is possible to ascertain the cost of process equipment items, a "guesstimate" of installed plant may be derived by use of a selling price factor. This factor is obtained by dividing the selling price (4) by the process equipment cost (2).

TABLE 1—Cost Data

TYPE	Unit	B. H. P. 200	400	600	1000	2000	3000
A. Motor-Driven Centrifugal							
1. Compressors	$M	....	53	70	99	157	205
2. Process Equipment Cost	$M	....	58	78	110	178	236
3. a Materials Cost	$M	....	77	103	146	235	313
b Labor Cost	$M	....	32	41	54	76	96
c Engineering & Fee Cost	$M	....	24	30	38	55	70
4. Selling Price	$M	....	133	174	238	366	479
5. Cost/HP	$/HP	....	333	290	238	183	160
6. Process Equipment Factor	....	....	2.29	2.23	2.16	2.06	2.03
B. Turbine-Driven Centrifugal							
1. Compressors	$M	32	50	65	89	138	178
2. Process Equipment Cost	$M	40	62	82	114	181	239
3. a Materials Cost	$M	53	85	111	155	247	328
b Labor Cost	$M	23	32	38	48	67	80
c Engineering & Fee Cost	$M	19	26	32	43	60	76
4. Selling Price	$M	95	143	181	246	374	484
5. Cost/HP	$/HP	475	358	302	246	187	161
6. Process Equipment Factor	..	2.38	2.31	2.21	2.16	2.07	2.02
C. Motor-Driven Reciprocating							
1. Compressors	$M	24	41	55	82	140	192
2. Process Equipment Cost	$M	28	48	66	98	168	230
3. a Materials Cost	$M	44	73	100	147	251	343
b Labor Cost	$M	22	35	44	60	94	127
c Engineering & Fee Cost	$M	18	28	35	50	79	101
4. Selling Price	$M	84	136	179	257	424	571
5. Cost/HP	$/HP	420	340	298	257	212	190
6. Process Equipment Factor	....	3.00	2.83	2.71	2.62	2.52	2.48
D. Steam-Driven Reciprocating							
1. Compressors	$M	39	62	81	115	....	....
2. Process Equipment Cost	$M	43	70	91	130	....	....
3. a Materials Cost	$M	58	95	126	183	....	....
b Labor Cost	$M	22	35	44	60	....	....
c Engineering & Fee Cost	$M	19	30	38	52	....	....
4. Selling Price	$M	99	160	208	295	....	....
5. Cost/HP	$/HP	495	400	347	295	....	....
6. Process Equipment Factor	....	2.30	2.29	2.29	2.27	....	....
E. Gas Engine Drive Reciprocating							
1. Compressors	$M	35	61	85	128	232	324
2. Process Equipment Cost	$M	39	68	95	143	259	362
3. a Materials Cost	$M	53	93	129	194	348	483
b Labor Cost	$M	22	35	44	60	94	127
c Engineering & Fee Cost	$M	19	30	39	55	91	120
4. Selling Price	$M	94	158	212	309	533	730
5. Cost/HP	$/HP	470	395	353	309	267	243
6. Process Equipment Factor	....	2.41	2.33	2.23	2.16	2.06	2.02

About the Author

Irwin J. Bromberg is an assistant chief estimator in charge of a group which prepares estimates and costs. He received his B.S. degree in chemical engineering from City College of New York in 1940, and his M.S. degree also in chemical engineering from Polytechnic Institute of Brooklyn in 1950. He is a member of the American Association of Costs Engineers.

Applied Hydrocarbon Thermodynamics

Part 5: Thermal Expansion Factors of Petroleum Liquid

Wayne C. Edmister and William S. Hanna
California Research Corporation, Richmond, Calif.

LIQUID PHASE DENSITIES are frequently calculated from a reference density and an expansion factor. Two such expansion factor correlations have been proposed. One of these, proposed by Watson[1] for pure hydrocarbons and chemicals, is a function of reduced temperature and pressure, while the other, originated by Jessup[4] and modified by Thiele and Kay,[5] is a function of temperature, pressure, and a characterizing modulus. Jessup's modulus is a simple function of viscosity and gravity.

The Watson expansion factor is a dimensionless quantity designed for estimating liquid density at one temperature and pressure from a known value at some other temperature and pressure. Watson's expansion factor is a function of reduced temperature and pressure for all types of substances. This function is of such a nature that the ratio of density to the factor is a constant for each substance at all reduced temperatures and pressures. This method is accurate but requires finding reduced conditions for application.

For petroleum fractions another method is more convenient. This method, which will be called the "Jessup's Modulus Method," uses a characterization parameter for correlating thermal expansion factors proposed in 1930 by Jessup[4] and improved in 1933 by Thiele and Kay.[5] Jessup's Modulus was defined as a function of kinematic viscosity at 100 F. and density at 60 F., as shown in Figure 5.1, where the equation defining the improved modulus is given. (The improved modulus is the square of Jessup's original modulus.) On this chart the modulus is plotted against viscosity and specific gravity.

In some cases viscosity is not a convenient property so alternate relationships for Jessup's Modulus were developed. UOP "K" is given as a function of gravity and ASTM distillation and also of gravity and viscosity at 100 F. by Watson et al.[6] Using these relationships and the definition of Jessup's Modulus, Figure 5.1, two alternate correlations for the modulus were prepared.

In Figure 5.2 Jessup's Modulus is given in terms of density and the UOP "K." The characterization factor lines were extrapolated in drawing Figure 5.2. In the other alternate, Figure 5.3, the ASTM slope and volumetric average boiling point are the parameters replacing UOP "K."

In the original work Jessup correlated the thermal expansion factor for oils with the modulus, temperature, and pressure. In improving the correlation, Thiele and Kay[5] included more observed data on specific volumes of various oils at different temperatures and pressures and modified the Modulus. Figure 5.4 is similar to the charts that Thiele and Kay developed for each pressure. The temperature factor, (ρ_T/ρ_{60}), is given as a function of temperature and Jessup's Modulus.

As an alternate to separate plots for each pressure, the expansion factor can be found from the value at atmospheric pressure. Figure 5.5 is such a pressure correction chart. The combined pressure-temperature factor, $(\rho_{T,P}/\rho_{60,0})$, is given in Figure 5.5 as a function of pressure and the temperature factor (ρ_T/ρ_{60}), found from Figure 5.4.

These temperature and pressure factor charts, i.e., Figures 5.4 and 5.5 were developed together in such a way as to extend the range of the Thiele and Kay[5] correlation and improve the accuracy near the critical. Revision, as well as extrapolation, was necessary because the Thiele-Kay correlation gave density values for saturated liquid conditions that drifted away from the actual values as the critical temperature was approached as follows:

Reduced Temperature T_r	Approximate Errors in Saturated Liquid Densities from Thiele-Kay Correlation: % High
0.80	2
0.85	5
0.90	8
0.95	12
0.98	19

The readings at $T_r = 0.90$, 0.95, and 0.98 were from straight extrapolations of the Thiele-Kay correlation. It was obvious from these errors that the extrapolation must be made in such a way as to get lower densities at the higher reduced temperatures.

The definitions and interrelationships of the various density factors involved here are:

$$(\rho_T/\rho_{60})_{P=0} = (\rho_{T,P}/\rho_{60,0}) \Big/ (\rho_P/\rho_0)_T \qquad (5.1)$$

The ratios in Equation 5.1 are defined as follows:

$\left(\frac{\rho_{T,P}}{\rho_{60,0}}\right)$ = combined temperature-pressure factor

$\left(\frac{\rho_P}{\rho_0}\right)_T$ = pressure factor

$\left(\frac{\rho_T}{\rho_{60}}\right)_{P=0}$ = temperature factor

where: $\rho_{T,P}$ = density at T, °F, and P, psig

$\rho_{60,0}$ = reference density at 60 F. and 0 psig

$\rho_{T,0}$ = hypothetical density at T, °F, and 0 psig

The value of the temperature factor is between 0 and 1.0, while the value of the pressure factor is above unity.

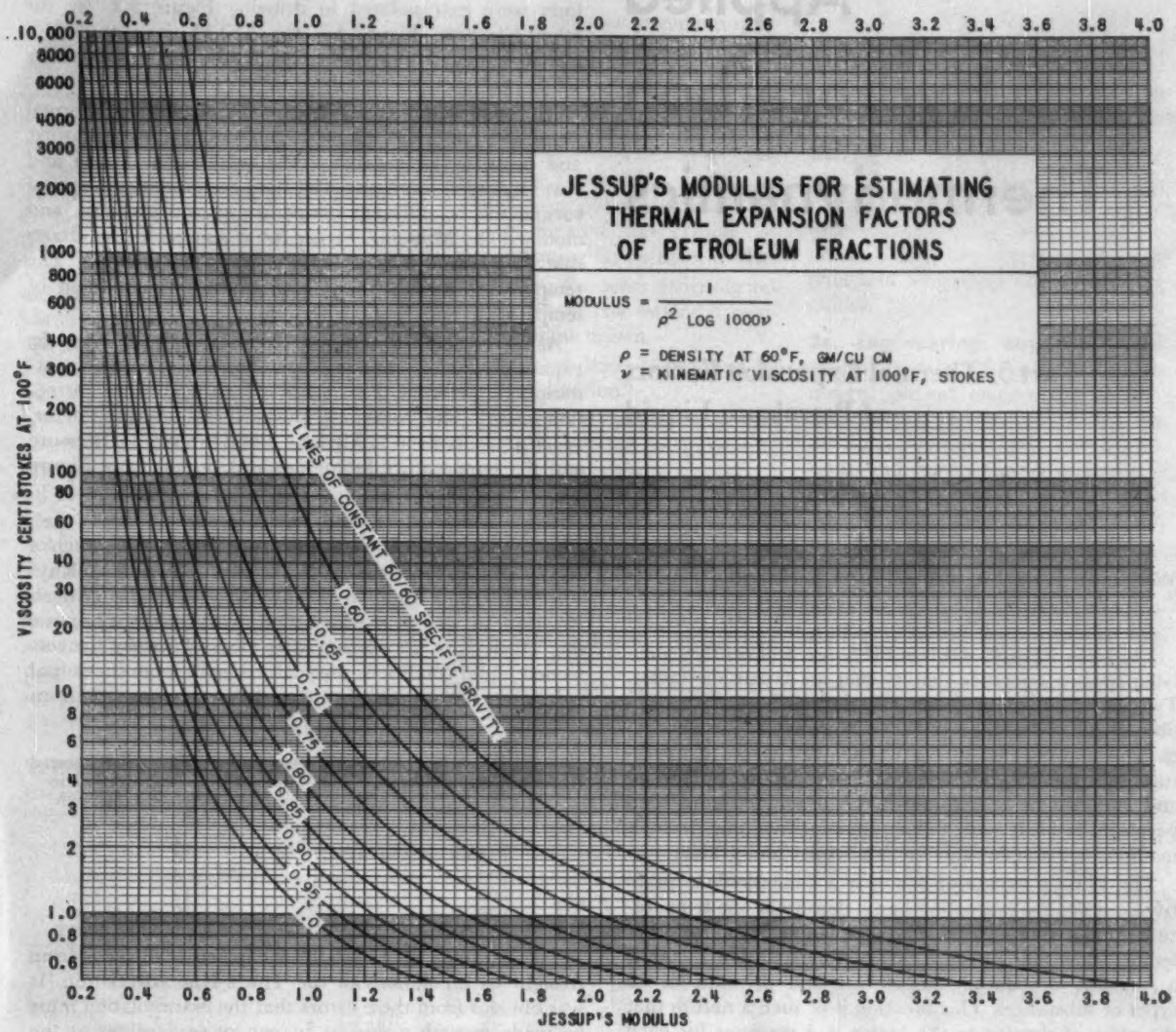


FIGURE 5.1—Jessup's Modulus Defined in Terms of Viscosity and Specific Gravity.

The value of the combined factor ($\rho_{T,P}/\rho_{60;0}$) at the critical point ranges from 0.40 for C_4 hydrocarbons to 0.35 for n-octane and toluene. Typical petroleum fraction values are 0.30 for a 20° API, 10.2 UOP "K" oil to 0.34 for a 60° API, 12.2 UOP "K" oil.

Values of the pressure correction are not given directly, but this correction is included in Figure 5.5, where the combined temperature-pressure factor is given as a function of the temperature factor and the pressure.

The density correction factors on Figures 5.4 and 5.5 were extended to estimated critical point values as the upper temperature limits. This extension is more exact for the temperature chart (Figure 5.4) than it is for the pressure chart (Figure 5.5). The reason for this is that critical temperature is a single valued function of Jessup's Modulus (see Figure 5.6) while critical pressure is a function of both Jessup's Modulus and UOP "K" (see Figure 5.7).

Figures 5.6 and 5.7 were prepared with values of T_c and P_c obtained for several hypothetical components from empirical correlations in terms of the variables: gravity, UOP "K," etc. Thus, these plots are derived and are not primary correlations of the measured critical properties with Jessup's Modulus.

The critical temperature relationship in Figure 5.6 was used to establish the upper temperature limits for the lines of constant Jessup's Modulus in Figure 5.4. The limiting value of (ρ_T/ρ_{60}) was arbitrarily taken as 0.1 in drawing the curves on Figure 5.4, i.e., in determining the Modulus intercept. This limiting value of the temperature factor was found by trial to result in curves that give the best agreement with observed density values.

As mentioned above, limiting values of the combined temperature-pressure factor on Figure 5.5 cannot be established definitely because critical pressure is not a single valued function of Jessup's modulus. The lines

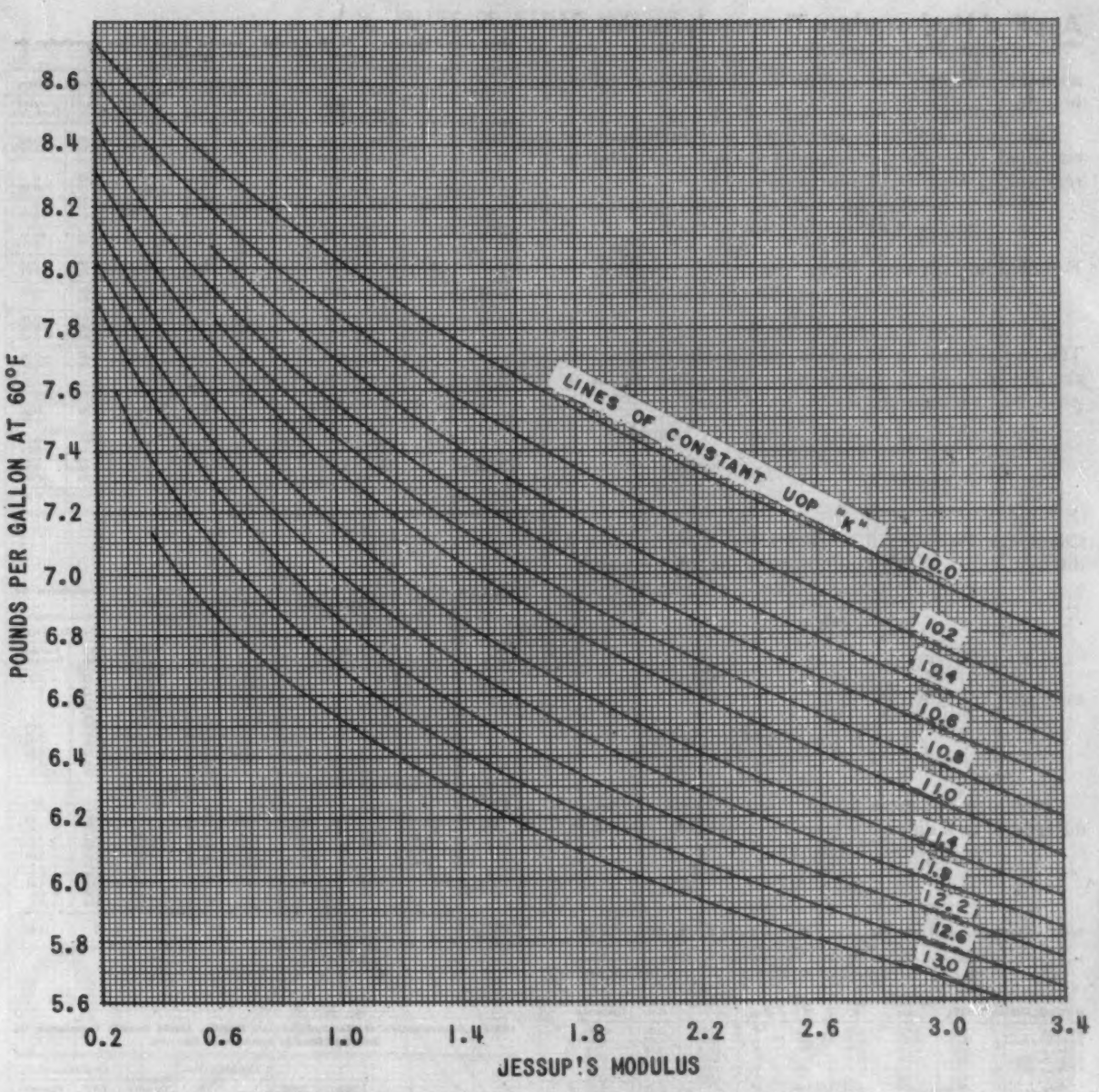


FIGURE 5.2—Jessup's Modulus Defined in Terms of Density and UOP "K."

shown on Figure 5.5 were drawn by extrapolation from the data of Thiele and Kay.[5] The proof of the correlation is the accuracy of predicting densities.

This modified Jessup's modulus method for estimating the effects of temperature and pressure on liquid density was applied to 84 observed data points to determine the accuracy of the correlation. Tables 5.1 through 5.5 give the comparisons for each data point and Table 5.6 summarizes the results.

The over-all accuracy of the method is shown to be very good. Except for the gasoline and kerosine data in Table 5.4, there are no significant deviations from the observed values of density. For these stocks the deviations are high at the highest temperatures, which are near the critical, as can be seen by the tabulated reduced temperature values. It is of interest to note that these high deviations are negative for the naphtha and positive for the gasoline. There is no apparent reason for this inconsistency. It appears to be in the data and not the correlation.

Coefficient of Thermal Expansion. By definition, the coefficient of thermal expansion is

$$\alpha = \frac{1}{T_2 - T_1}\left[\frac{V_2}{V_1} - 1\right] = \frac{1}{T_2 - T_1}\left[\frac{\rho_1}{\rho_2} - 1\right] \quad (5.2)$$

The coefficient of thermal expansion may be found from the Jessup Modulus correlation by estimating densities at two adjacent temperatures and substituting T and ρ values in Equation 5.2. Precision in reading these charts is not high enough at the lower temperatures to get

adequate readings for computing accurate α values, however.

The first temperature derivative of volume may be estimated from the coefficient of thermal expansion by rearranging Equation 5.2 as follows:

$$\alpha = \rho_1\left(\frac{V_2 - V_1}{T_2 - T_1}\right) = \rho\,\frac{dV}{dT}$$

For constant pressure

$$\left(\frac{\partial V}{\partial T}\right)_P = \frac{\alpha}{\rho} \qquad (5.3)$$

This relationship is useful in calculating temperature changes in adiabatic pumping and expanding oil, as in pipe line transmission.

For reversible and adiabatic (isentropic) pumping

$$\left(\frac{\partial T}{\partial P}\right)_S = \frac{\left(\frac{\partial V}{\partial T}\right)_P}{C_P} \qquad (5.4)$$

Combining Equations 5.3 and 5.4 and changing from a differential to a difference form gives the following equation for temperature change in isentropic pumping:

$$(\Delta T)_S = \frac{144}{778}\,\frac{\Delta P}{\rho C_P}\,\alpha T \qquad (5.5)$$

For irreversible and adiabatic (isenthalpic) expansion, as in pipe line flow:

$$\left(\frac{\partial T}{\partial P}\right)_H = \frac{T\left(\frac{\partial V}{\partial T}\right)_P - V}{C_P} \qquad (5.6)$$

Combining Equations 5.3 and 5.6 and changing from a differential to a difference form for isenthalpic expansion

$$(\Delta T)_H = \frac{144}{778}\,\frac{\Delta P}{\rho C_P}(\alpha T - 1) \qquad (5.7)$$

TABLE 5.1—Evaluation of Modified Jessup's Modulus Liquid Density Correlation On API 44 Hydrocarbon Data

	DATA FROM API PROJECT 44						CORRELATION	
HYDROCARBON	°API	Lb./Gal. 60° and 0 psig	UOP "K"	°F.	Psig	Lb./Gal. at t and P	Lb./Gal.	Percent Deviation
n-Octane	68.3	5.893	12.68	200	0	5.093	5.04	—0.98
n-Pentadecane	51.5	6.437	12.86	500	0	4.588	4.85	—0.61
n-Eicosane	46.8	6.606	13.06	600	0	4.816	4.76	—1.04
3-Ethylpentane	69.6	5.858	12.40	200	0	5.253	5.23	—0.38
2,5-Dimethylhexane	70.9	5.819	12.66	200	0	5.259	5.21	—0.95
1-Heptene	69.9	5.848	12.43	100	0	5.685	5.70	+0.17
1-Octene	64.9	5.996	12.41	240	0	5.307	5.24	—1.13
1-Nonene	61.2	6.114	12.42	240	0	5.454	5.38	—1.26
1-Decene	58.2	6.211	12.46	240	0	5.561	5.53	—0.54
1-Undecene	55.8	6.290	12.50	240	0	5.654	5.64	—0.18
1-Tetradecene	50.8	6.463	12.66	240	0	5.868	5.85	—0.34
Benzene	28.3	7.375	9.73	180	0	6.766	6.69	—1.03
Toluene	30.6	7.269	10.14	200	0	6.569	6.54	—0.45
Ethylbenzene	30.6	7.268	10.36	280	0	6.332	6.30	—0.47
Metaxylene	31.2	7.243	10.43	280	0	6.347	6.30	—0.79
n-Propylbenzene	31.6	7.225	10.61	330	0	6.149	6.19	—0.65
Absolute Average	...	....	....	...	.	....	...	0.686

TABLE 5.2—Evaluation of Modified Jessup's Modulus Liquid Density Correlation On Jessup's Data At 712 PSIG

				CONDITION		Observed Density	CORRELATION	
	°API	Lb./Gal.	UOP "K"	°F.	psig	Lb./Gal.	Density Lb./Gal.	Percent Deviation
Spindle Oil, Pa.	30.7	7.264	12.2	302 572	712	6.593 5.792	6.56 5.75	—0.46 —0.69
Gas Oil, L.A.	30.4	7.278	11.6	302 572	712	6.551 5.64	6.55 5.82	0 —0.35
Gas Oil, Okla.	28.7	7.365	11.4	302 572	712	6.613 5.679	6.61 5.66	0 0
Gas Oil, Mid. Cont.	29.1	7.337	11.5	302 572	712	6.602 5.692	6.61 5.66	+0.15 —0.53
Gas Oil, Pa.	44.9	6.679	12.3	302 572	712	5.947 4.998	5.92 4.90	—0.50 —2.00
Lub. Oil, Okla.	25.8	7.491	12.0	302 572	712	6.819 6.024	6.81 6.01	—0.15 —0.33
Absolute Average	...	....	...	...	...	....	...	0.43

TABLE 5.3—Evaluation of Modified Jessup's Modulus Liquid Density Correlation On Jessup's Data At Various Pressures

				CONDITIONS		Observed Density Lb./Gal.	CORRELATION	
	°API	Lb./Gal.	UOP "K"	t, °F.	P, psig		Lb./Gal.	Percent Deviation
Cracked Gaso., L.A. Basin	52.7	6.396	11.9	122 140	284 568.8	6.16 6.09	6.20 6.10	+0.65 +0.02
Aviation Gaso., W. Va.	72.1	5.785	12.3	104 156	284.4 568.8	5.62 5.41	5.62 5.40	0 —0.18
Aviation Gaso., Okla.	71.5	5.802	12.3	131 156	282.2 711.0	5.51 5.44	5.51 5.40	0 —0.74
Spindle Oil, Pa.	30.7	7.264	12.2	167 572	142.2 426.5	6.88 5.77	6.98 5.76	+0.14 —0.17
Gas Oil, L.A. Basin	30.4	7.278	11.6	167 572	284.4 568.8	6.84 5.81	6.95 5.85	+0.14 +0.71
Gas Oil, Okla.	28.7	7.355	11.4	167 572	284.4 711.0	7.03 5.86	6.99 5.86	—0.57 0
Gas Oil, Mid. Cont.	29.1	7.337	11.5	302 302 572	426.5 711.0 711.0	6.59 6.60 5.69	6.60 6.62 5.68	+0.15 +0.34 —0.18
Gas Oil, Pa.	44.9	6.679	12.3	437 302	284.4 568.8	5.44 5.98	5.41 5.89	—0.55 —0.67
Lub. Oil, Okla.	25.8	7.491	12.0	302 572	284.4 568.8	6.81 6.03	6.79 6.03	—0.29 +0.16
Lub. Oil, Gulf	20.1	7.773	11.5	302 572	284.4 568.8	7.05 6.25	7.06 6.30	+0.14 +0.64
Lub. Oil, Pa.	29.9	7.30	12.3	302 572	426.6 568.8	6.61 5.88	6.60 5.84	+0.15 —0.68
Lub. Oil, Pa.	29.0	7.341	12.5	302 572	284.4 711.0	6.65 5.89	6.67 5.92	+0.30 +0.51
Absolute Average								0.32

TABLE 5.4—Evaluation of Modified Jessup's Modulus Liquid Density Correlation On Bahlke and Kay Data for Saturated Liquid

				CONDITIONS			Observed Density Lb./Gal.	CORRELATION	
STOCK	°API	Lb./Gal.	UOP "K"	t, °F.	T_r	P, psig		Lb./Gal.	Percent Deviation
Naphtha	57.1	6.246	11.9	362 381.8 381.8 424.4 424.4 468.9 499.6 499.6 537.2 569.9 569.9*	0.889 0.909 0.909 0.949 0.849 0.891 0.921 0.921 0.956 0.988 0.988	81.1 80.0 186.8 134.5 298.3 287.8 270.3 377.6 339.3 399.2 481.3	4.96 4.64 4.67 4.40 4.44 4.16 3.99 4.00 3.56 3.18 3.34	4.87 4.74 4.77 4.65 4.46 4.30 3.90 3.90 3.46 2.93 3.00	+ 0.2 + 2.1 + 2.1 + 1.1 + 0.9 + 0.96 — 2.25 — 2.25 — 2.24 — 4.7 —10.0
Absolute Average	...	....	...	....	....	....	....	...	5.4
Gasoline	57.2	6.24	12.1	361.8 422.5 422.5 441.8 455.2 455.2 495.0 516.5 537.5 554.1†	0.773 0.830 0.830 0.846 0.860 0.860 0.896 0.916 0.936 0.954	175.6 271.5 430.2 293.3 322.8 374.3 404.3 480.3 464.3 521.3	4.90 4.54 4.57 4.40 4.31 4.325 4.013 3.88 3.58 3.44	4.96 4.69 4.72 4.52 4.46 4.51 4.26 4.06 3.90 3.74	+ 1.22 + 3.3 + 3.3 + 2.7 + 3.96 + 4.4 + 6.2 + 6.95 + 8.9 + 8.7
Absolute Average	...	....	...	....	....	....	....	...	4.96

* T_r—0.988. † T_r—0.955.

TABLE 5.5—Evaluation of Modified Jessup's Modulus Liquid Density Correlation On Zeitfuchs Data At Atmospheric Pressure

				CONDITIONS		Observed Density Lb./Gal.	CORRELATION	
STOCK	°API	Lb./Gal.	UOP "K"	t, °F	P, psig		Lb./Gal.	Percent Deviation
Gas Oil	28.0	7.387	11.3	212 363	0 0	6.896 6.389	6.89 6.37	—0.16 —0.31
Water White Distillate	35.1	7.072	11.5	212.8 364	0 0	6.556 6.013	6.55 6.01	—0.15 0
Kerosine	39.4	6.894	11.3	135 176	0 0	6.645 6.501	6.61 6.48	—0.45 —0.31
Engine Distillate	45.2	6.556	11.4	134 212	0 0	6.306 6.010	6.28 5.94	—0.48 —1.16
Gasoline	53.4	6.371	11.8	134 176	0 0	6.090 5.922	6.09 5.89	0 —0.51
Absolute Average	...	....	...	...	.	....	...	—0.35

TABLE 5.6
Summary of Evaluation of Modified Jessup's Modulus Liquid Density Correlation

LIQUID	T, °F.	psig	Data Source	Number of Points	Absolute Average Percent Deviation
Hydrocarbons	100–600	0	API 44	16	0.7
Gasolines, Gas Oils, Lubes	100–570	280–710	Jessup	37	0.4
Naphtha	360–550	80–530	Bahlke and Kay	11	5.0*
Gasoline	360–550	80–530	Bahlke and Kay	10	5.0*
Gasolines, Kerosine, Gas Oils	130–365	0	Zeitfuchs	10	0.4
Total	.....	.....	.....	84	1.6

* Deviations for naphtha are mostly negative while the gasoline deviations are positive.

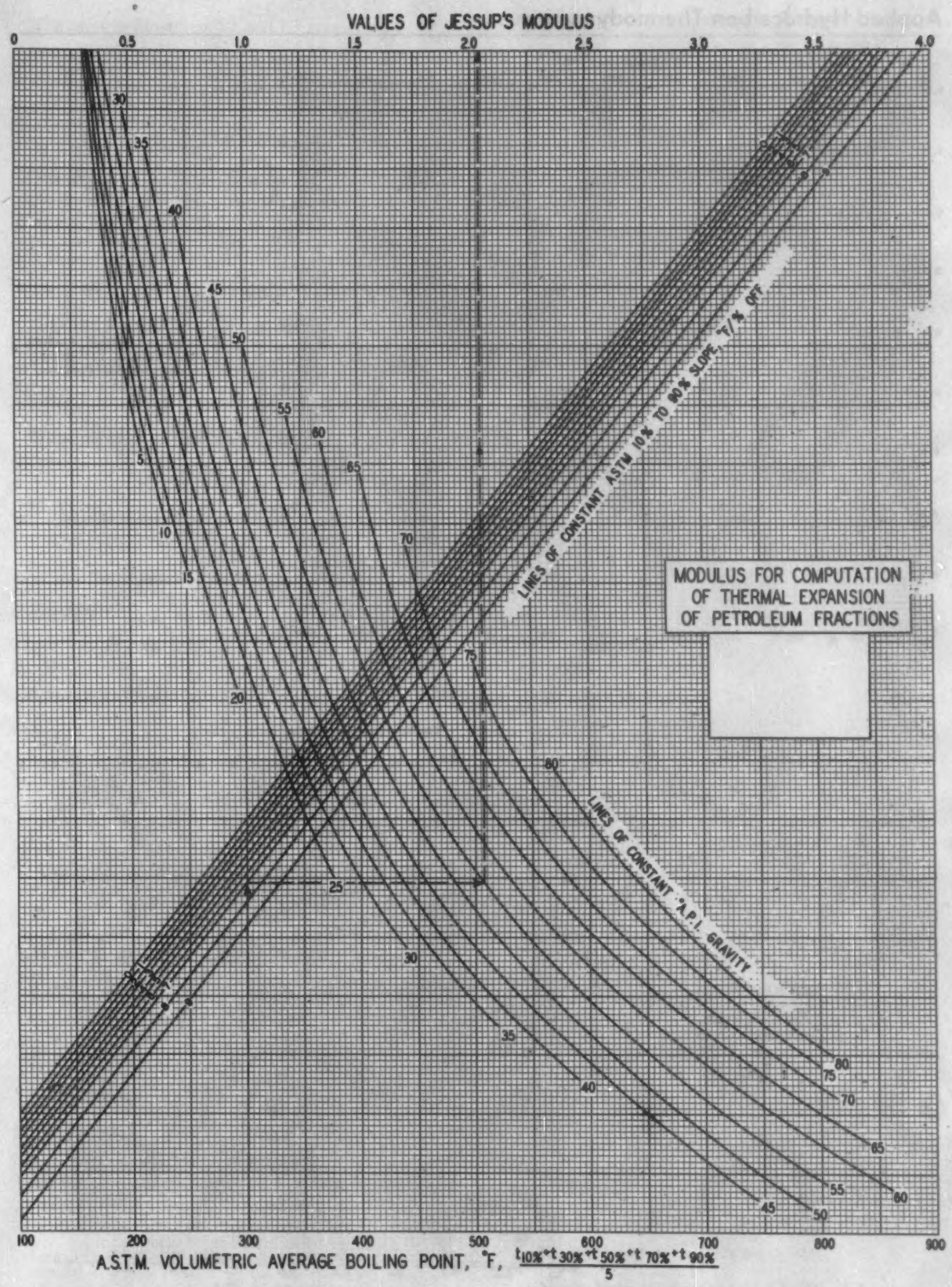


FIGURE 5.3—Jessup's Modulus in Terms of ASTM Slope, Volumetric Average Boiling Point, and Gravity.

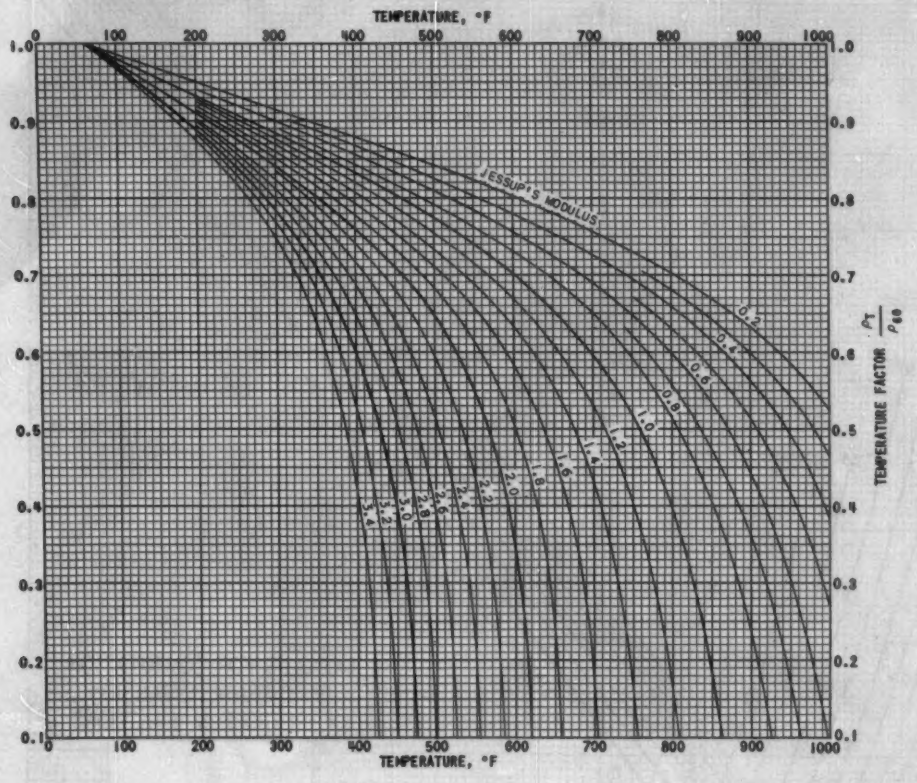


FIGURE 5.4
Thermal Expansion Factors for Petroleum Fractions, Uncorrected for Pressure.

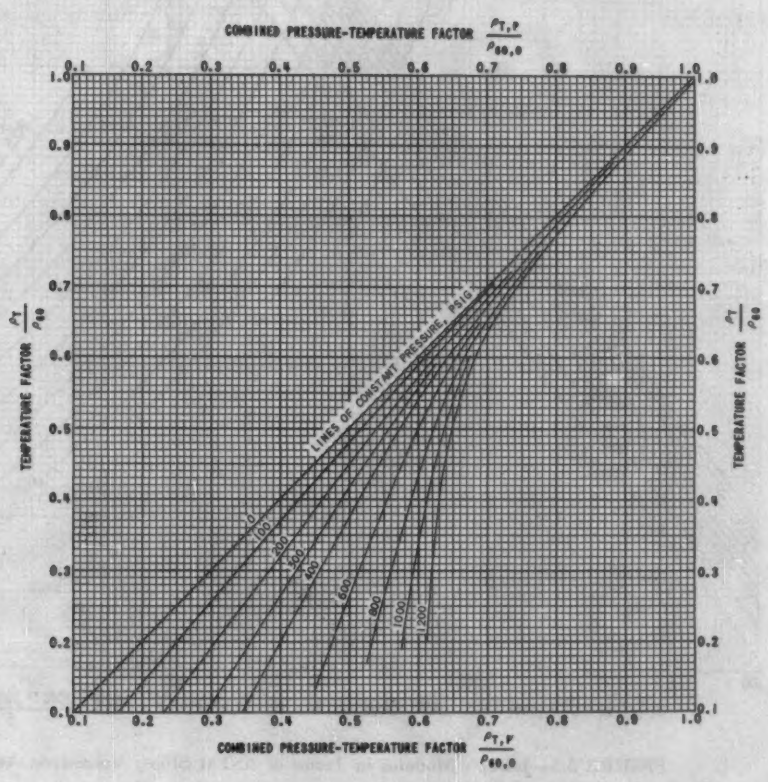


FIGURE 5.5
Thermal Expansion Factors for Petroleum Fractions, Corrected for Pressure.

The units in Equations 5.5 and 5.7 are:

$\Delta P = P_2 - P_1 =$ pressure change in lb/sq in
$\Delta T = T_2 - T_1 =$ temperature change, °F
$T =$ mean fluid temperature, °R
$\rho =$ fluid density, lb/cu ft
$C_P =$ heat capacity, Btu/lb, °F
$\alpha =$ thermal expansion factor in reciprocal degrees Fahrenheit

Illustration. Find temperature rise for pumping a crude from 0 psi to 1000 psi at 100 F. average temperature. Also find temperature rise for throttling (through a valve or a long line) same oil from 1000 psi to 0 psi also at 100 F. average temperature.

Data: UOP "K" = 11.6, 35.4° API, $C_P = 0.46$.

Solution: From Figure 5.2, the Jessup Modulus = 1.0.

From Figure 5.4: $\frac{\rho_T}{\rho_{60}} = 0.98$ at 100 F. The pressure effect is negligible at this low temperature.

Substituting in Equation 5.2 gives

$$\alpha = \frac{1}{100 - 60}\left[\frac{1.0}{0.98} - 1\right] = 0.0005$$

T_{av} °R = 100 + 460 = 560° R

$\Delta P = 1000$ for pumping

$\Delta P = 1000$ for flowing

Solution:

$$\text{By Eqn. 5.5: } (\Delta T)_S = \frac{144{,}000\ (560)\ (0.005)}{(778)\ (51.7)\ (0.46)} = 2.2 \text{ F.}$$

$$\text{By Eqn. 5.7: } (\Delta T)_H = \frac{144{,}000\ [(560)\ (0.0005) - 1]}{(778)\ (51.7)\ (0.46)} = 5.6 \text{ F.}$$

Total temperature rise for adiabatic pumping of the same crude to 1000 psi and flowing to 0 psi at 100 F. average temperature.

Total $\Delta T = 2.2 + 5.6 = 7.8$ F.

The 5.6 F. rise for pressure drop during flow covers the heat generated by pipe friction (represented by unity in brackets) corrected for the expansion (represented by αT in brackets).

It is of interest to note that αT is greater than unity for a gas so that Equation 5.7 would give a temperature decrease if applied to the isenthalpic expansion of a gaseous fluid.

The α used in the above calculation should be the coefficient of thermal expansion at constant pressure. Where α varies with pressure, a mean value of α should be used.

The above-type calculation is of value in calculating temperature rises and pump efficiencies from physical properties of the oil. References are made to previous observations[7] and to an experimental temperature rise curve.[8] Calculations by the method illustrated above have been shown[9] to agree with measured temperature rises.

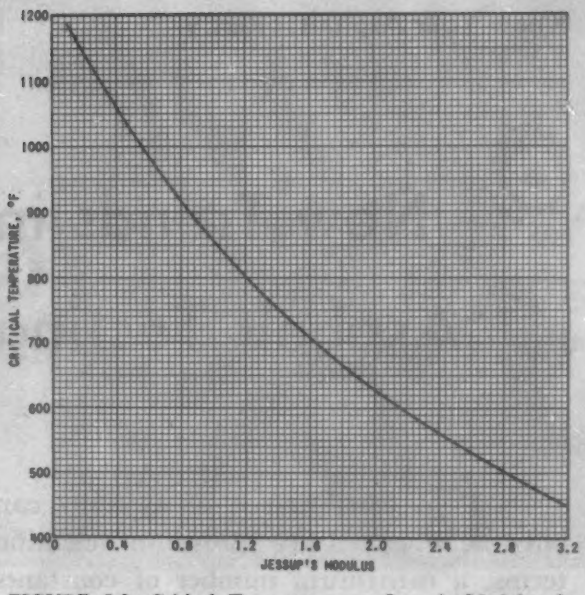


FIGURE 5.6—Critical Temperature vs Jessup's Modulus for Petroleum Fractions.

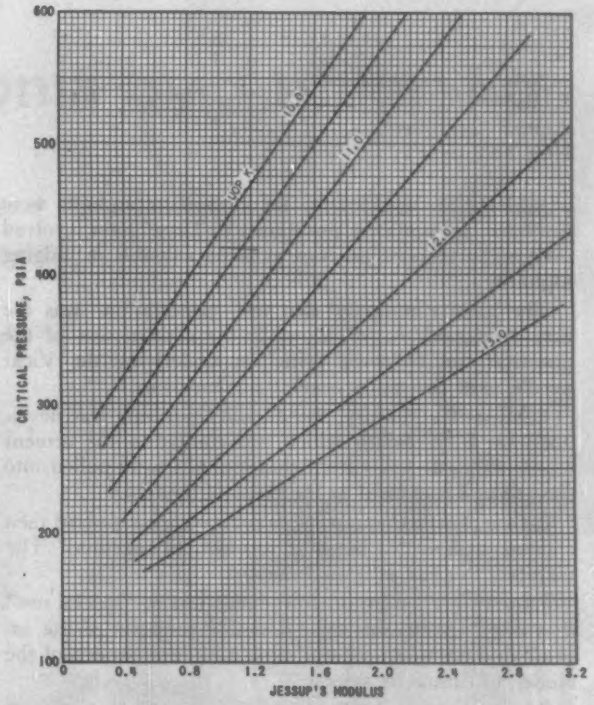


FIGURE 5.7—Critical Pressure vs Jessup's Modulus for Petroleum Fractions.

LITERATURE CITED

[1] Watson, K. M., Ind. Eng. Chem., 35, 398 (1943).
[2] Fortsch, A. R., and Wilson, R. E., Ind. Eng. Chem., 16, 789 (1924).
[3] Zeitfuchs, E. H., Ind. Eng. Chem., 16, 128 (1925).
[4] Jessup, R. S., Bur. Std. J. of Res., 5, 958 (1930).
[5] Thiele, E. W., and Kay, W. B., Ind. Eng. Chem., 25, 894 (1933).
[6] Watson, K. M., Nelson, E. F., and Murphy, G. B., Ind. Eng. Chem., 27, 1460 (1935).
[7] Cameron, A., "The Isothermal and Adiabatic Compressibilities of Oil," Institute of Petroleum Journal, November, 1945.
[8] Jennings, G. P., and Meade, L. P., "Determination of Pump Efficiencies From Fluid Temperature Rise," API Pipeline Conference, Houston, May 17, 1956.
[9] Ludwig, M., Private Communication, August, 1956.

Next, Part 6: Improved Mollier Charts for Hydrocarbons

Know Your Asphalts—Part 9

New Trends in Asphalt Testing

True performance of asphalts can only be depicted by common scientific terms, a minimum number of constants and basic apparatus.

E. J. Barth
Asphalt Consultant
New York City

VARIOUS METHODS for evaluating asphalts were discussed in previous installments. These have evolved over many years of practice as being valuable in judging asphalts.

The most commonly used test—penetration—was the first developed. A. W. Dow, in the construction of the penetrometer, followed principles underlying the Vicat needle used in testing cement for hardness.

Early in the century, the ductility machine was developed by F. P. Smith which was similar to the cement tensile strength test, except that asphalts were pulled into threads and measured at the point of breaking.

Before penetration test apparatus became standard men chewed asphalt "to see if it would hold together." The temperature was at least standard.

Efforts were made to evolve some test or "special test" that might point out some desirable property of the asphalt or more often present some optimistic aspects of the binder to futher its sales.

For example, asphalts which "didn't pull" that is, were short in ductility, were undesirable to say the least. An enormous number of test methods resulted over the years. Outside of a few, such as mathematical calculations for determining temperature susceptibility and the penetration index method of Pfeiffer and van Doormaal, new relationships between various properties or between the tests themselves have not been discovered. As to the relationship between properties and actual performance from a physical engineering standpoint for asphalts in pavement or in roofing products, little has been achieved until very recently.

The modern highway of today is a masterpiece of scientific construction. The materials going into these modern highways must be evaluated in engineering terms and properties described in absolute physical and scientific units. The asphaltic binders must be tested with methods describing their properties in units such as is done in the steel, cement, rubber, plastics and printing ink industries. The units must be universally intelligible and interchangeable from one area to another.

In new evaluation methods now being developed viscosity will be basic to a better understanding of asphaltic materials. In most temperature ranges of measurements it will supplant the less accurate penetration test. The micro-viscosimeter (Miles) is another instrument unique for determining asphalt viscosities in any penetration range and at any specified temperature. A new system of asphalt physics, or more correctly rheology, will employ the new tools of this science. It will describe asphalts in terms of viscosity or a derivative property of viscosity, such as complex flow, modified penetration index or a type of elastic modulus, as has already been developed and termed "stiffness factor."

The instrument needed will be primarily the viscosimeter. Although the softening point apparatus with the penetration machine as an alternate may be used in the case of very hard bitumens. The penetration test is, barely, a form of viscosity test.

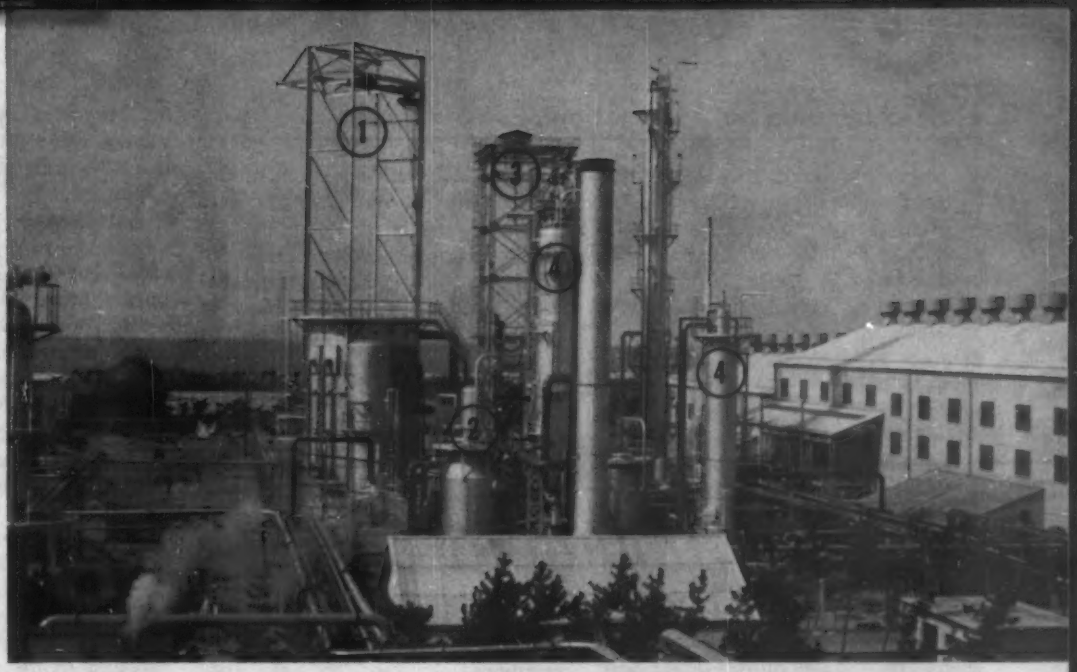
Newer methods for the ductility test to be developed along basic rheological lines will relegate it to the past. It is not a quality test and has recently been shown to have no relationship to paving engineering practice or be meaningful in the theory of pavements. Indirectly this test appears, or the property of ductility appears, to be related in some fashion (not measurable) to adhesiveness. At best qualitatively determined, adhesiveness apparently is connected to the nature of the components constituting the asphalt.

The empirical tests used today for determining brittleness, pliability, cohesion and elongation will be supplanted by rheological measurements evaluating these properties. Perhaps these designations are aspects of the same intrinsic property and will probably be found related to some flow constant or viscosity itself.

Asphalts perform as thin films showing various rheological properties. These need to be determined by simplified procedures based on the flow concept and behavior of the bitumen at the various temperatures used in their manufacture and application. The final evaluation will be precise and free from rule of thumb measurements. The resultant series of constants can be transposed and related to properties closely allied to those of the asphalt and other engineering materials. For instance, tensile strength will be better visualized in absolute units. Asphalts will compare very high or low to other materials of construction. A common scientific language using proper physical terms will depict a clear picture of asphalt performance and constitution when simplified by a minimum number of constants and basic apparatus.

The rheological descriptions of bitumen properties can then be applied and related directly to application and performance. The development of the concept of the "stiffness modulus" for asphalts is a significant advance in this direction.

Part 10 will appear in an early issue.



Over-all view of the ammonia plant showing (left to right) primary reformer, synthesis gas converter, and synthesis gas purification columns with the compressor building in the background.

Now—Ammonia by Automation

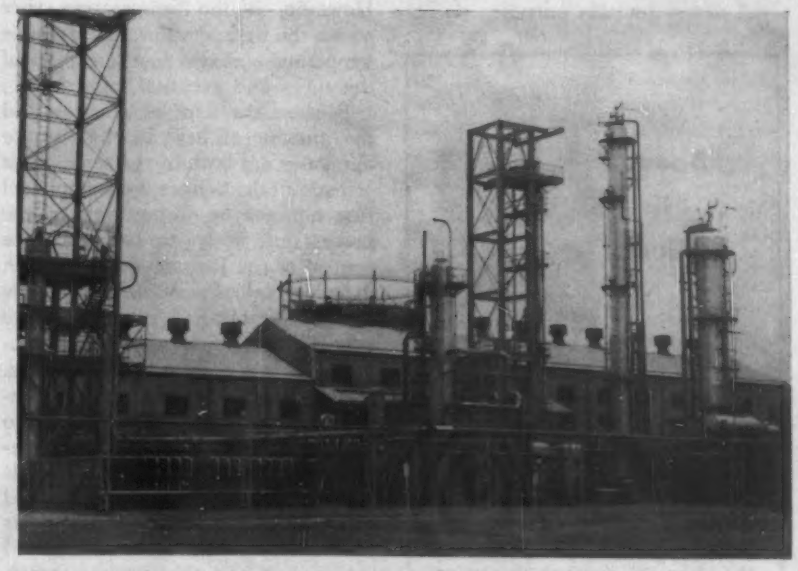
Here are the types of controls and their function in the first completely automatic ammonia plant.

S. Bresler, Chemical Construction Corporation, New York City

AUTOMATION, EVER extending its potentialities, now reaches to Niigata in Japan. There for the first time, automation completely directs the synthesis of ammonia from natural gas.

The plant, built for Nihon Gas Corp., is designed to produce 100 metric tons of ammonia per day and requires only standby operating personnel. Even more remarkable, the instrumentation consists of standard equipment and requires no special apparatus. This was possible through the unique application of existing devices.

Safety controls monitor all critical points, giving visual and oral alarm when the immediate attention of an operator is required. As precise control of operating variables is available, utility requirements can be minimized. Thus, there is no need to provide safety margins of reforming



On the left is the synthesis converter with intercoolers in the right foreground. Further to the right is the copper liquor system for carbon monoxide removal. The hot potassium carbonate carbon dioxide removal and regeneration towers are on the far right.

steam or scrubbing solutions. As a result, thermal efficiency is very high.

Approximately half of the instruments were procured in the U. S. and half in Japan.

In the process, methane reacts catalytically with steam to form a mixture of hydrogen and mixed carbon oxides. Air is introduced to complete the oxidation and provide the necessary nitrogen. The carbon monoxide formed is then converted to carbon dioxide and additional hydrogen. The gas mixture is scrubbed with absorbent solutions to remove the oxides of carbon, compressed to 350 atmospheres, and then passed over a catalyst to form ammonia.

While these basic processes are not novel, each stage in this plant was designed for minimum operating labor consistant with reasonable instrumentation costs and maximum safety.

Gas Reforming. The first step is the production of hydrogen from natural gas, or the reforming of methane in the presence of steam, to produce hydrogen, carbon dioxide and carbon monoxide. Conservative design based on commercially available materials indicate this stage may best be carried out in a catalyst reactor operating at about 100 psig and 1300 C. The direct fired furnace,[1] with the process gas flowing through vertical tubular catalyst beds, is particularly well suited for this purpose. To obtain safe, optimum operation of this furnace, the following controls were provided:

1. A recorder-controller maintains a constant, predetermined ratio between methane and steam flow to the furnace. The operation of this controller is checked continually by a steam-gas infra-red analyzer which analyzes the gas leaving the secondary reformer.

To change plant output only the steam flow controller need be reset. The methane rate will change accordingly. As will be seen, all other flows change correspondingly. However, most changes are made not in direct proportion, but as required to maintain preset optimum operating conditions.

2. Changes in rate of flow of process methane are reflected by changes in the gas header pressure. Any pressure change is transmitted as a pneumatic signal to the methane compressor controllers. The signal is retransmitted to a hydraulic system which varies the timing of suction valve lifters, varying the compressor output, as required, to maintain constant gas header pressure—and therefore gas metering—regardless of demand. Power for compression is almost directly proportional to gas usage.

3. Temperature control of the furnace is very important, since the methane reaction is endothermic. However, if the temperature rises above the desired value the excessive temperature may cause creeping of the tubes and eventual failure.

Because the heat of reaction and the amount of heat in the furnace flue gases are both of the same order of magnitude, neither a constant fuel rate nor a rate proportional to the process gas flow can be used as a control of the fuel gas ratio. Instead, imbedded thermocouples, near the bottom of catalyst tubes, measure maximum temperatures. The temperatures are averaged and recorded. A pneumatic output, from the recorder, varies the rate of fuel gas to maintain the average catalyst temperature at the present value. Individual temperatures also are wired to a multipoint recorder and contacts provided to sound an alarm should any one of the temperatures reach an excessive value.

Fuel gas pressure is kept constant by the use of hydraulically operated suction valve lifters. Thus flow control is accurate and compressor power minimized.

4. Aspirator type burners are used, adjustment of primary air to fuel gas rate occurring automatically over the burner range. Once the burners are set for optimum burning, they need not be changed unless major changes are made in furnace output.

5. The last factor to be considered is the draft in the furnace. If this is allowed to vary as the volume of fuel gas varies, greater variations in secondary air rate would occur, resulting in less efficient combustion. Also, if the furnace draft ever became positive, hot gases might leak from the furnace into operating areas. Therefore, to insure constant draft at all times, a motor operated damper is placed in the exhaust stack line, the motor operator taking its impulse from a pressure transmitter located near the top of the furnace.

As a further safety measure, a steam jet is placed inside the furnace stack. Should the induced draft fan fail, this jet will immediately become operative, expelling hot flue gases and preventing overheating of the furnace roof.

Reformed gas leaving the furnace is passed over a second catalyst bed in the presence of compressed air. The oxygen, reacting with hydrogen in the gas, forms additional steam and leaves nitrogen for the ammonia synthesis. The heat of reaction increases the gas temperature, promoting the steam-methane reaction and reducing the methane content of the synthesis gas.

Theoretically, the best method of control of air flow would be based on hydrogen analysis of the gas stream. However, hydrogen analysis instruments are not considered sufficiently sturdy or reliable for complete control at such a sensitive point. Therefore, that the most advantageous method of regulating the air flow is by ratio-control. With both process gas and air ratio-controlled, the hydrogen-nitrogen ratio remains constant.

Nevertheless, a continuous hydrogen recorder, analyzing the gas leaving the CO shift converter, enables an operator to check the performance of the plant and correct the air-process steam ratio when required. Temperatures in the catalyst bed are recorded, and an alarm will sound

About the Author

Sidney Bresler is a project engineer for Chemical Construction Co., New York. He received his B.S. degree in chemical engineering from College of the City of New York, then joined Celanese Corp. of America. In 1944 he was with the Army in Los Alamos, then in 1947 he joined Chemico, first in pilot plant, then as a process engineer, and as a project engineer. He received his M.S. degree in chemical engineering from Polytechnic Institute of Brooklyn in 1956.

should the temperature become too high.

As in the case of process gas and fuel gas, a pressure controller maintains constant air pressure, regardless of usage.

The mixture of reformed gases, nitrogen and steam next enter a reformed gas waste heat boiler, generating approximately half the process steam requirements. The remaining steam requirement comes from the reform furnace flue gas waste heat boiler.

Both boilers are equipped with standard controls, including level controller, relief valve, level alarms, etc. Failure of a boiler feed water pump causes an alarm to sound and the automatic start-up of a stand-by spare pump. Should the water level in a boiler continue to fall, an emergency supply of water is injected into the boiler by a steam jet.

Leaving the reformed gas waste heat boiler, the gases pass over a shift catalyst, where the CO content is reduced and additional hydrogen is formed. The reformed gas mixture is sent to the potassium carbonate reboiler, where most of its latent and sensible heat is extracted while regenerating rich carbonate solution. Finally the gas is cooled in a water scrubbing tower.

Optimum heat recovery is obtained in the following manner:

- First, the flow of gas to the carbonate reboiler is controlled by the temperature of the carbon dioxide and steam leaving at the top of the regenerator. Should this temperature get too high, which would be the result of inefficient utilization of heat to vaporize water in the reboiler, a control valve opens and part of the reform gas bypass the reboiler.
- Second, the rate of flow of water to the scrubbing tower is controlled by the temperature of the cooled gas. Thus, efficient gas cooling is obtained at all times, regardless of water temperature or gas flow rate.
- Third, the hot water, leaving the scrubbing tower, is used to regenerate the copper solution required by the final gas purification system and then to preheat boiler feed water.

Compression. The cooled, reformed gases are compressed in the first stage of a multi-stage compressor. A pressure controller activated by the suction pressure is used to regulate the capacity of the compressor. Since the pressure of process gas to the reformer as well as the suction pressure of the main gas compressor are held constant, all intermediate pressures are also invariant. Thus, catalytic and purification processes are unaffected by throughput.

Purification

The compressed gases are scrubbed with potassium carbonate solution to absorb carbon dioxide. Flow rates of carbonate streams are ratio controlled in accordance with the gas flow to the absorber. Naturally, all columns and knockout drums are level controlled, and a pressure controller is used to maintain a pre-set pressure on the regenerator.

The scrubbed gases are piped back to the main gas compressor. Final purification is accomplished by scrubbing with a refrigerated cuproammonium "copper solution," followed by scrubbing with aqueous ammonia.

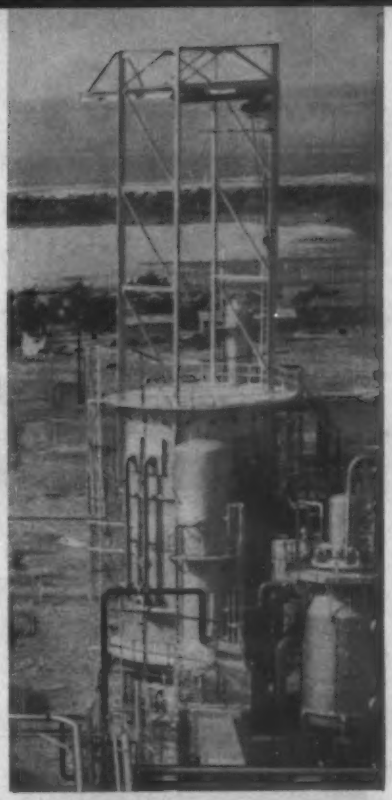
The copper solution is regenerated by heating it with hot water obtained from the water scrubber. The flow rate of the hot water is regulated by the temperature of the copper liquor leaving the copper solution heater.

Similarly, the flow rate of refrigerant ammonia to the copper solution cooler is regulated by a refrigerant vapor pressure control valve actuated by the temperature of the exiting copper solution. Should both high pressure copper solution pumps fail, this vapor pressure control valve shuts automatically, thus increasing the refrigerant pressure and temperature and preventing freezing of the copper solution.

The flow rates of the copper solution and of aqua are maintained constant, as such control is not significant with respect to thermal economy. The purifier gas is continually monitored for CO and CO_2 by infra-red analysis. Any increase in these impurities beyond the allowable limit causes the sounding of an alarm.

Gases, primarily carbon monoxide with small amounts of ammonia, leave the top of the regeneration tower, and are piped to the flue gas waste heat boiler, where they are burned and the heat utilized in generating additional steam.

Synthesis. The purified gas is further compressed to 5200 psig by the main gas compressor, and enters the synthesis loop. Conversion of hydrogen and nitrogen to ammonia is accomplished over a promoted catalyst in a standard NEC loop, of proved efficiency.



The first step in the production of hydrogen from natural gas is done in the primary reformer shown above.

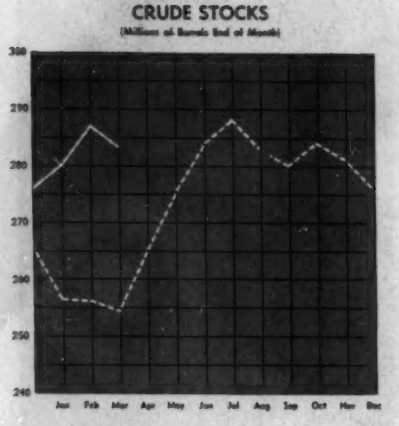
The loop contains an automatic scanning system, by means of which thermocouples in the ammonia converter are continuously scanned. The hottest temperature is determined and compared with a reference temperature. The gas flow through the converter is modified as necessary to maintain optimum conditions in the catalytic bed. Thus, this system compensates for changes in gas throughput without requiring any change in circulator output.

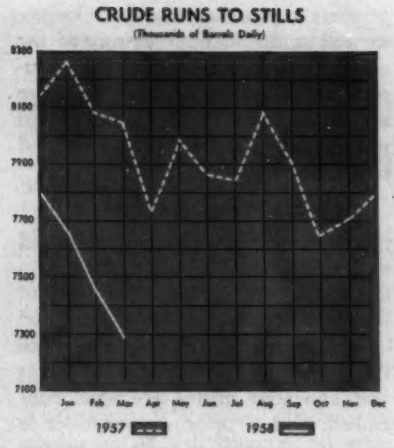
Final control of the loop is achieved by having the purge rate dependent on loop pressure, purging just enough gas to maintain the loop at the desired level.

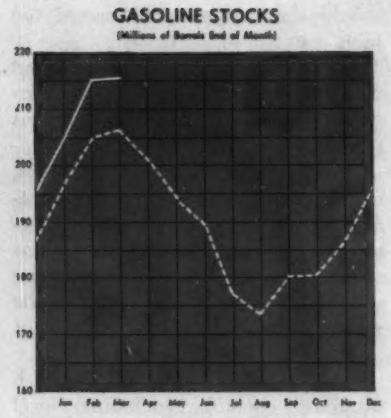
Liquid ammonia separators are equipped with level control valves. As liquid is formed, it leaves the separating vessels, is degassed, and flows into a low pressure storage sphere. It is only at this point, when liquid is pumped to one of the nearby processing plants or to the loading platform, that the first non-automatic operation occurs.

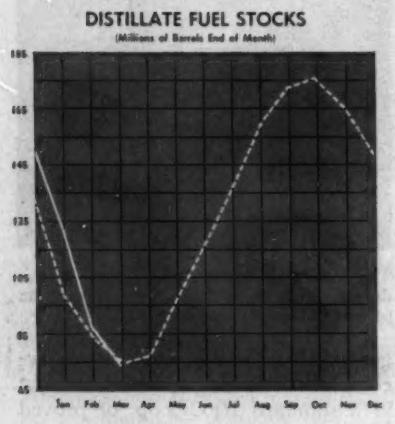
LITERATURE CITED

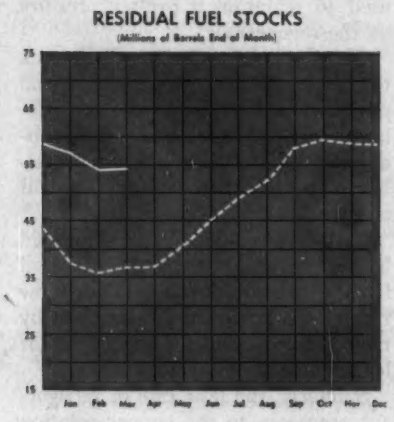
[1] L. J. McCarthy, Fluid Heater, U.S.P. 2,660,519; 2,712,303; 2,737,159

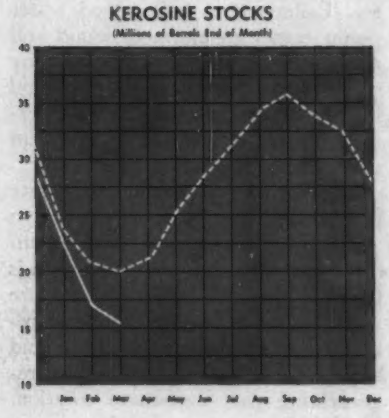












Taking Stock

This month, PETROLEUM REFINER presents "Taking Stock" in its new format. You will notice we have added a demand factor and a year-to-date total for products. This will enable you to get a much clearer picture of the U.S. monthly oil trends.

U. S. Monthly Oil Trends

(THOUSANDS OF BARRELS DAILY)

	MARCH			Feb.	JANUARY-MARCH		
	1958	1957	% Diff.	1958	1958	1957	% Diff.
U. S. Crude Oil Production	6,273	7,717	—18.7	6,821	6,647	7,624	—12.8
U.S. Nat. Gas Liquids Prod.	800	826	— 3.2	815	810	833	— 2.8
U.S. Total Imports	1,593	1,464	+ 8.8	1,494	1,590	1,440	+10.4
East Coast Crude Imports	882	627	+40.7	666	805	611	+31.8
Total Crude Imports	1,033	836	+23.6	807	960	808	+18.8
Total Refined Products	560	629	—11.0	687	630	633	— 0.1
Total New Supply	8,666	10,007	—13.4	9,130	9,046	9,898	— 8.6
Stock Changes All Oils (Daily)	—580	—16	.....	—1,000	—789	—721	.....
Total Demand All U.S. Oils	9,246	10,023	— 7.8	10,130	9,836	10,618	— 7.4
Gasoline Demand	3,617	3,783	— 4.4	3,430	3,527	3,682	— 4.2
Distillate Fuel Demand	2,125	2,182	— 2.6	2,959	1,001	2,676	—62.6
Residual Fuel Demand	1,464	1,748	—16.3	1,758	1,665	1,931	—13.8
Domestic Demand, All Oils	9,016	8,982	+ 0.4	9,895	9,683	9,016	+ 7.4
Export Demand, All Oils	230	1,040	—77.9	235	235	940	—75.0
Crude Runs U.S. Refineries	7,297	8,047	— 9.3	7,447	7,473	8,138	— 8.2
Domestic Crude Runs	6,398	7,270	—12.0	6,567	6,596	7,327	—10.0
Foreign Crude Runs	899	777	+15.7	880	921	811	+13.6

	TOTAL U.S. STOCKS Millions of Barrels End of Month				STOCKS EAST OF CALIFORNIA Millions of Barrels End of Month			
	March			Feb.	March			Feb.
	1958	1957	% Diff.	1958	1958	1957	% Diff.	1958
Crude Oil	283.9	254.9	+11.4	287.8	240.3	224.4	+ 7.1	243.5
Gasoline	215.6	206.7	+ 4.3	215.2	186.9	179.5	+ 4.1	186.5
Distillate Fuel Oil	74.8	76.2	— 1.8	88.0	62.3	67.3	— 7.4	73.8
Residual Fuel Oil	54.9	37.4	+46.8	54.3	25.5	25.0	+ 2.0	25.9
Kerosine	15.5	20.2	—23.3	17.2	16.7	19.9	—16.1	16.9

Source: Except for latest two months, all data from U.S. Bureau of Mines. Data for last two months from American Petroleum Institute weekly reports and U. S. Bureau of Mines weekly crude stock report; except U. S. Natural Gas Liquids Production and Demand figures which are estimated by World Oil.

Petroleum Refiner
May, 1958

Foundation Design Handbook For Stacks and Towers

The same principles apply in both stacks and towers. Use this method in making your calculations for either.

V. O. Marshall, Tennessee Eastman Company, Kingsport, Tenn.

From the viewpoint of the foundation designer, stacks and towers may be divided into two general classifications, depending on the method utilized to maintain them in a vertical position; (a) Self-supporting, which resist the overturning forces by the size, shape and weight of the foundation; (b) Guyed, in which the overturning forces are resisted by guy wires. It is obvious that the conditions affecting the design of foundations for these two types will not be the same, and that it is necessary to treat them separately.

STACKS AND TOWERS are closely related as far as foundation design is concerned—in fact, the same principles apply. In the case of stacks, the brick lining is a variable load, corresponding to, and requiring the same treatment as the liquid, insulation, etc., in a tower. This discussion will be based on the design of tower foundations, however, it should be kept in mind that it is also applicable to stacks.

2. Self-Supporting Tower

There are two main considerations in designing the foundation for a self-supporting tower; (a) soil loading (b) stability. The foundation must be of such size and shape that the load on the soil below will not exceed the maximum load which it will safely support. The foundation must also maintain the tower in a vertical position, so that it will not be overturned by the maximum forces acting upon it.

No direct method of calculating the size of the foundation has been developed, therefore, it must be determined by trial and error. A size is assumed, and the soil loading and stability calculated. If the results are not satisfactory, another assumption is made, and the calculations repeated.

3. Soil Loading

(See Section 20 for complete definition of terms.)

The soil loading may be determined by the following formula:

$$S = S_1 + S_2 \qquad (1)$$

where

S = total unit soil loading (lbs./sq. ft.)
S_1 = unit soil loading due to dead load (lbs./sq. ft.)
S_2 = unit soil loading due to overturning moment (lbs./sq. ft.)

4. Dead Load

The dead load S_1 may be determined as follows:

$$S_1 = \frac{W}{a} \qquad (2)$$

where

a = area of base of foundation (sq. ft.)
W = total weight on soil (pounds) calculated by the following equation:

$$W = W_t + W_a \qquad (3)$$

W_t = Minimum dead load (pounds), which is the weight of the empty tower plus the weight of the foundation, including the earth fill on top of the base.
W_a = Weight of auxiliary material and equipment supported by the tower and foundation (pounds), which should include the liquid in the tower, insulation, platforms, piping, etc. (Does not include weight of tower)

This is a revised article which was previously published in the August, 1943 issue of PETROLEUM REFINER. All copies of that issue, all reprints and all copies of the 1940 Process Handbook, in which the original article was reproduced, failed to meet the demand for this engineering data.

When the author considered the revision he extended the subject to include actual design of foundation types commonly required in the erection of refinery vessels. The result is a thorough study of a subject which continues to hold a forefront position in refinery engineering.

Reprints will be provided in quantity sufficient to include the demand that has extended into construction fields outside of refining. Price $1.00 per copy.

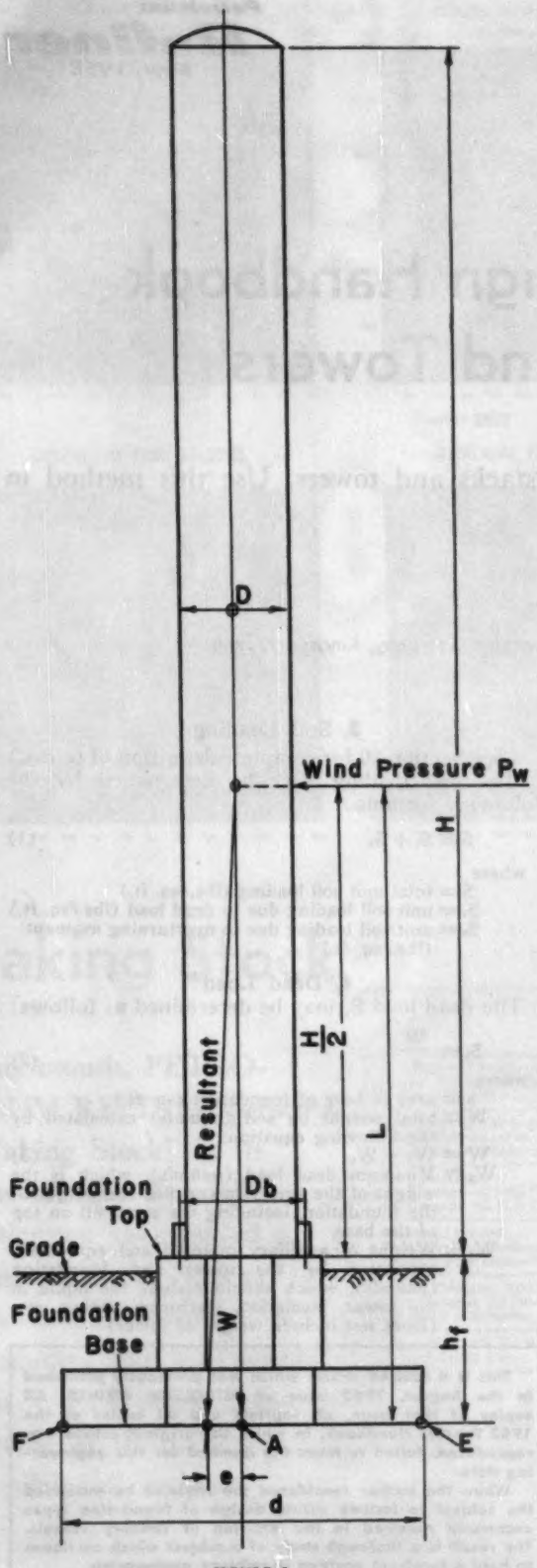


FIGURE 1
Foundation for self-supporting tower.

5. Overturning Load

The overturning load S_z is the result of the overturning moment. Under ordinary conditions, the only force tending to overturn the tower is the wind pressure.

The magnitude of the wind pressure is obviously a function of the wind velocity, which varies in different localities. In many instances laws have been enacted which state the wind velocity or wind pressure to be used for design purposes.

The United States Weather Bureau has proposed the following formula:

$$p = 0.004\frac{B}{30}V^2 \qquad (4)$$

where
p = wind pressure on a flat surface (pounds/sq. ft.)
B = barometric pressure (inches H_g)
V = velocity of wind (miles per hour)

For a barometric pressure of 30 inches, the formula becomes:

$$p = 0.004V^2 \qquad (5)$$

It has been found that the wind pressure on a cylindrical tower is about 60 percent of that on a flat surface. For a cylindrical tower, therefore, formula (5) becomes:

$$p_c = 0.0025V^2 \qquad (6)$$

where
p_c = wind pressure on the projected area of a cylindrical tower (pounds per square foot).

In most localities, a wind velocity of 100 miles per hour is considered the maximum. This gives a pressure of 25 pounds per square foot on the projected area of the tower, which is the figure generally used for design purposes. It should be emphasized, however, that this figure is subject to variation in different localities, and that local laws should not be overlooked in this connection.

(Note: As a matter of interest, the wind pressure on an octagon shaped stack is considered to be 70 percent of that on a flat surface.)

Figure 1 represents a tower, mounted on a concrete foundation. The wind pressure (P_w) tends to rotate the tower and foundation about point A at the intersection of the vertical centerline and the base of the foundation. This rotating effect produces an overturning moment which can be calculated as follows:

$$M_f = P_w L \qquad (7)$$

where
M_f = overturning moment about the base of the foundation (foot pounds)
P_w = total wind load (pounds) to be calculated as follows:

$$P_w = p_c D_c H \qquad (8)$$

L = lever arm of wind load (feet) to be calculated as follows:

$$L = h_f + \frac{H}{2} \qquad (9)$$

D_c = diameter of tower measured over insulation (feet)
H = height of tower (feet)
h_f = height of foundation (feet)

It should be noted that all dimensions are stated in feet, giving the overturning moment (M_f) in foot pounds. This avoids the use of the excessively large numbers encountered with the usual inch pound units. Care should be taken, however, to

use consistent units, that is foot pounds, in all calculations.

The stress, or load, on the soil resulting from the overturning moment (M_t) varies from point to point, and the maximum load (S_2) can be calculated as follows:

$$S_2 = \frac{M_t}{Z} \qquad (10)$$

where

Z = section modulus of the base of the foundation. (Note: Z to be based on dimensions in feet.)

The value of (Z) can be expressed as follows:

$$Z = \frac{I}{c} \qquad (11)$$

where

I = moment of inertia of the base of the foundation (based on dimensions in feet).

c = distance from neutral axis of foundation base to point of maximum stress (feet).

Having calculated (S_1) and (S_2) as explained above, the total soil load under maximum dead load conditions can be determined by equation (1).

This maximum soil load occurs at the edge of the foundation, designated as F, and is frequently referred to as the "toe pressure." It is obvious that the maximum toe pressure (S) should never exceed the safe bearing load of the soil in question.

6. Stability

It should be noted that (S_2) is positive at point F, and negative at E (Figure 1). In other words, the wind load causes compressive stresses on the soil to the left of point A, the maximum compression occurring at F, and tensile stresses of equal magnitude to the right of A, the maximum tension occurring at E.

Since the earth has no strength whatever in tension, it is obvious that the sum of the stresses at any point must be positive. In other words, the base of the foundation must exert a compressive force on the soil over its entire area, otherwise a tensile stress will be produced at E, which means that the tower and foundation will be unstable, and likely to be overturned by the action of the wind.

It was shown by equation (1) that the maximum soil load is equal to ($S_1 + S_2$). Since the value of S_2 at point E is negative, the minimum soil load (which obviously occurs at point E) is ($S_1 - S_2$).

It is very important to note that the condition of poorest stability occurs immediately after the tower is mounted on the foundation, and before the insulation, platforms, piping, liquid, etc., are in place. In calculating the stability, therefore, (S_1) must be replaced by (S_{1m}) as follows:

$$S_{1m} = \frac{W_t}{a} \qquad (2\text{-a})$$

where

S_{1m} = minimum soil loading due to dead load (lbs./sq. ft.)

The minimum soil loading which can ever exist, therefore, is found to occur at point E when the dead load is at its minimum value, and can be expressed as follows:

$$S_{min} = S_{1m} - S_2 \qquad (1\text{-a})$$

Therefore, in order that (S_{min}) may always be positive, thereby assuring a stable condition at all times, (S_{1m}) must never be less than (S_2). In a perfectly balanced system, (S_{1m}) is exactly equal to (S_2), in which case

$$S_{min} = S_{1m} - S_2 = 0 \qquad (1\text{-d})$$

Although, such a balanced system is rarely possible, it is the ideal condition. The upward force at E due to the overturning moment is exactly balanced by the dead load, so that the stress at E is zero. The stress at F in such cases is the minimum which can exist and still maintain a stable system.

It should be emphasized that while (S_{1m}) is frequently greater than (S_2) it should never be less.

It should also be emphasized that the stability is based on the minimum dead load (W_t) while the soil loading is based on the maximum dead load (W).

7. Example No. 1

Design the concrete founation for a tower 4 ft. dia. by 54 ft. high, including a 4 ft. skirt, and weighing 30,000 lbs. empty. The insulation, platforms and piping weigh 9000 lbs., the maximum wind velocity is 100 miles per hour, and the frost line at the location of the proposed installation is 4 ft. below grade. The maximum safe soil loading is 2000 pounds per square foot.

Solution

Since the frost line is 4 ft. below grade, the foundation will be 6 ft. deep, with the top 1 ft. above grade, making the bottom of the foundation 5 ft. below grade, or 1 ft. below the frost line.

The foundation will be octagon shape, which is recommended for such cases, as it combines the features of stability, ease of construction and minimum material better than other shapes. The top course will have a short diameter of 6 ft. since the tower is 4 ft. dia. and allowance must be made for foundation bolts, etc. The short diameter of the base will be assumed to be 13.5 ft. The thickness of the base will depend on the bending and shearing forces (see Sections 19 to 19h incl.), however, for the time being the thickness will be assumed to be 2 ft.

The weight of the foundation will be calculated as follows (all slide-rule figures):

Area of 6 ft. octagon = $0.828\ d^2 = 0.828 \times 6^2 = 29.8$ sq. ft.
Volume of top course = 4 ft. × 29.8 = 119.2 cu. ft.
Area of base (octagon) (a) = $0.828 \times 13.5^2 = 151$ sq. ft.
Volume of base = 2 ft. × 151 = 302 cu. ft.
Total volume = 119.2 + 302 = 421.2 cu. ft.
Weight of concrete =
421.2 cu. ft. × 150 lbs./cu. ft. = 63,000 lbs.
Volume of earth fill
(4 ft. — 1 ft.) × (151 sq. ft. — 29.8 sq. ft.) = 363 cu. ft.
Weight of earth fill = 363 cu. ft. × 90 lbs./cu.ft. = 32,700 lbs.
Weight of empty tower = 30,000 lbs.
W_t = 30,000 + 63,000 + 32,700 = 125,700 lbs.
W_s will be as follows:

Insulation, platforms, piping, etc.	= 9,000 lbs.
Water required to fill the tower (4 ft. dia.) (50 ft. high)	= 39,500 lbs.
Total (W_s)	= 48,500 lbs.

W = 125,700 + 48,500 = 174,200 lbs. (from equation 3)
a = 151 sq. ft.

$$S_t = \frac{174{,}200 \text{ lbs.}}{151 \text{ sq. ft.}} = 1155 \text{ lbs./sq. ft.} = \text{Maximum dead load on soil (equation 2)}$$

Allowing 3" for the thickness of the insulation,

the effective diameter of the tower exposed to the action of the wind is 4.5 ft. A wind velocity of 100 miles per hour is equal to 25 pounds per sq. ft. of projected area.

Therefore:

$p_e = 25$ lbs./sq. ft.
$D_e = 4.5$ ft.
$H = 54$ ft.
$P_w = 25 \times 4.5 \times 54 = 6080$ lbs. (equation 8)
$h_f = 6$ ft.

$$L = 6 + \frac{54}{2} = 33 \text{ ft. (equation 9)}$$

$M_f = 6080 \times 33 = 200{,}000$ foot pounds (equation 7)
$Z = 0.1016\ d^3 = 0.1016 \times 13.5^3 = 248.5$

From equation (10)

$$S_s = \frac{200{,}000 \text{ ft. pounds}}{248.5} = 803 \text{ lbs./sq. ft.} = \text{maximum soil load due to overturning moment.}$$

The total maximum soil load (toe pressure) can be calculated from equation (1) as follows:

$$S = 1155 + 803 = 1958 \text{ lbs./sq. ft.}$$

TABLE 1
Elements of Octagonal Base

Short Diam. (Feet)	Area a (Sq. Ft.)	Length of side (Feet)	Neutral Axis to Extreme Fiber c (Feet)	Section Modulus Z	Radius of Gyration r (Feet)
3	7.45	1.242	1.62	2.74	0.772
3.5	10.6	1.449	1.89	4.37	0.900
4	13.2	1.656	2.16	6.50	1.029
4.5	16.8	1.863	2.43	9.23	1.158
5	20.7	2.070	2.70	12.68	1.286
5.5	25.0	2.277	2.98	16.45	1.415
6	29.8	2.484	3.25	21.90	1.542
6.5	34.8	2.691	3.51	27.90	1.67
7	40.5	2.898	3.78	34.90	1.80
7.5	46.5	3.105	4.06	42.80	1.93
8	52.8	3.312	4.33	52.00	2.06
8.5	59.5	3.519	4.59	62.70	2.17
9	66.8	3.726	4.87	74.10	2.31
9.5	74.5	3.933	5.13	87.30	2.44
10	82.8	4.140	5.41	101.60	2.57
10.5	91.2	4.347	5.67	117.60	2.70
11	100.0	4.554	5.94	135.00	2.83
11.5	109.8	4.761	6.22	154.10	2.96
12	119.5	4.968	6.48	174.50	3.09
12.5	140.0	5.382	7.03	221.00	3.34
13	129.2	5.175	6.76	198.00	3.22
13.5	151.0	5.589	7.30	248.50	3.47
14	162.0	5.796	7.57	277.00	3.60
14.5	174	6.003	7.83	309.20	3.73
15	186	6.210	8.11	342.00	3.86
15.5	199	6.417	8.38	375.00	3.99
16	212	6.624	8.65	416.00	4.12
16.5	226	6.831	9.02	455.00	4.24
17	240	7.038	9.19	497.00	4.37
17.5	253	7.245	9.46	543.00	4.50
18	268	7.452	9.72	590.00	4.63
18.5	283	7.659	10.00	624.00	4.76
19	299	7.866	10.25	652.00	4.89
19.5	315	8.073	10.55	731.00	5.02
20	332	8.280	10.81	811.00	5.14
20.5	348	8.487	11.08	873.00	5.27
21	365	8.694	11.35	933.00	5.40
21.5	383	8.901	11.62	1005.00	5.53
22	401	9.108	11.90	1085.00	5.66
22.5	420	9.315	12.17	1145.00	5.78
23	438	9.522	12.43	1240.00	5.92
23.5	458	9.729	12.71	1320.00	6.04
24	477	9.936	12.98	1400.00	6.17
24.5	497	10.143	13.25	1490.00	6.29
25	518	10.350	13.52	1585.00	6.43
25.5	539	10.557	13.79	1685.00	6.56
26	560	10.764	14.07	1787.00	6.68
26.5	582	10.971	14.33	1900.00	6.82
27	603	11.178	14.61	2010.00	6.94
27.5	526	11.385	14.88	2110.00	7.07
28	650	11.592	15.15	2220.00	7.20
28.5	672	11.799	15.42	2350.00	7.33
29	695	12.006	15.68	2470.00	7.46
29.5	720	12.213	15.96	2600.00	7.58
30	745	12.420	16.23	2740.00	7.71
31	795	12.834	16.77	3021.00	7.97
32	848	13.248	17.31	3330.00	8.23
33	902	13.662	17.85	3660.00	8.48
34	958	14.076	18.38	3980.00	8.75
35	1015	14.490	18.92	4370.00	9.00
36	1075	14.904	19.47	4730.00	9.26
37	1134	15.318	20.01	5130.00	9.51
38	1195	15.732	20.55	5580.00	9.77
39	1260	16.146	21.09	6020.00	10.04
40	1325	16.560	21.65	6500.00	10.28

This loading is satisfactory, as the soil will safely support 2000 lbs./sq. ft.

From equation (2-a)

$$S_{1m} = \frac{125{,}700 \text{ lbs.}}{151} = 830 \text{ lbs./sq. ft.}$$

This is the dead load under the worst stability condition, and since it is greater than the overturning stress ($S_s = 803$), the soil below the foundation will always be under compression at all points, thus indicating that the foundation is stable.

Usually it is found that the first assumption as to foundation size is not correct, in which case, another assumption is made, and the calculations repeated.

It is interesting to note that the soil loading of 2000 lbs./sq. ft. allowed in this problem is rather low, as good clay soil will usually support about 4000 lbs./sq. ft. Care should always be taken, to ascertain the actual load carrying value of the soil at the site of construction.

8. Eccentricity

It will be noted that there are two forces acting on foundations of the type under consideration; (a) The dead load, acting in a vertical direction; (b) the wind load, acting in a horizontal direction. The combined action of these two forces, that is, their resultant, has the same effect as an eccentric vertical load. As explained previously, it is not necessary to calculate the eccentricity in order to determine the stability of the foundation. Several methods have been proposed, however, which make use of the eccentricity, and since there are definite relationships between eccentricity and stability, they will be explained as a matter of interest.

The eccentricity can be calculated as follows:

$$e = \frac{M_f}{W_t} \qquad (12)$$

where e = eccentricity (feet)

Note: The value of (e) calculated by equation (12) is the maximum value, as the dead load (W_t) is minimum. The eccentricity for other conditions of dead loading may be obtained by substituting the proper weight in place of (W_t).

It has been shown by previous discussion that the following relationships exist:

$$S_{1m} = \frac{W_t}{a} \qquad (2\text{-a})$$

$$S_s = \frac{M_f}{Z} \qquad (10)$$

$$Z = \frac{I}{c} \qquad (11)$$

combining equations (10) and (11)

$$S_s = \frac{M_f c}{I} \qquad (13)$$

rearranging equation (12)

$$M_f = W_t e \qquad (12a)$$

combining equations (12a) and 13)

$$S_s = \frac{W_t e c}{I} \qquad (14)$$

It was shown by equation (1-a) that in order to avoid tensile stress at E (which would make the foundation unstable), the maximum value of (S_2) is as follows:

$$S_2 = S_{1m} \tag{15}$$

thus making the value of (S_{min}) equal to zero, as shown by equation (1-d).

Substituting the values obtained by equations (2-a) and (14) in equation (15)

$$\frac{W_t ec}{I} = \frac{W_t}{a} \tag{16}$$

The value of I can be expressed as follows:

$$I = ar^2 \tag{17}$$

where

r = radius of gyration of base (feet)

substituting in equation (16)

$$\frac{W_t ec}{ar^2} = \frac{W_t}{a} \tag{18}$$

Hence, the maximum value of (e) for stable conditions is

$$e_{max} = \frac{r^2}{c} \tag{19}$$

In the case of a circular foundation

$$c = \frac{d}{2} \tag{20}$$

Substituting in equation (19)

$$e_{max} = \frac{2r^2}{d} \tag{21}$$

Substituting the value of (r^2) in equation (21), the maximum value of (e) for a circular base is $\left(\frac{d}{8}\right)$, thus confirming the common rule that in a stable foundation the resultant must fall within the middle-quarter of the diameter of a circular base.

In the case of the octagon base usually used for tower foundations, the maximum allowable eccentricity becomes

$$e_{max} = 0.122\,d \tag{22}$$

The area surrounding the center of the base, within which the resultant causes a compressive stress over the entire base, is known as the kernel or kern.

It follows, then, that the resultant must always fall within the kern of the base in order to assure stability.

In example No. 1 (Section 7), it was shown that the foundation is stable, since the overturning stress (S_2) is less than the minimum dead load stress (S_{min}).

The stability of this foundation will now be calculated (as example No. 2) on the basis of the eccentricity for the purpose of comparing the two methods.

From equation (12) the eccentricity is

$$e = \frac{M_t}{W_t} = \frac{200{,}000 \text{ foot pounds}}{125{,}700 \text{ lbs.}} = 1.59 \text{ ft.}$$

From equation (22), the maximum permissible eccentricity is

$$e_{max} = 0.122d = 0.122 \times 13.5 = 1.64 \text{ ft.}$$

Inasmuch as the actual eccentricity (1.59) is less than the maximum permissible eccentricity (1.64) the foundation is stable, thus confirming the conclusion reached in Section 7.

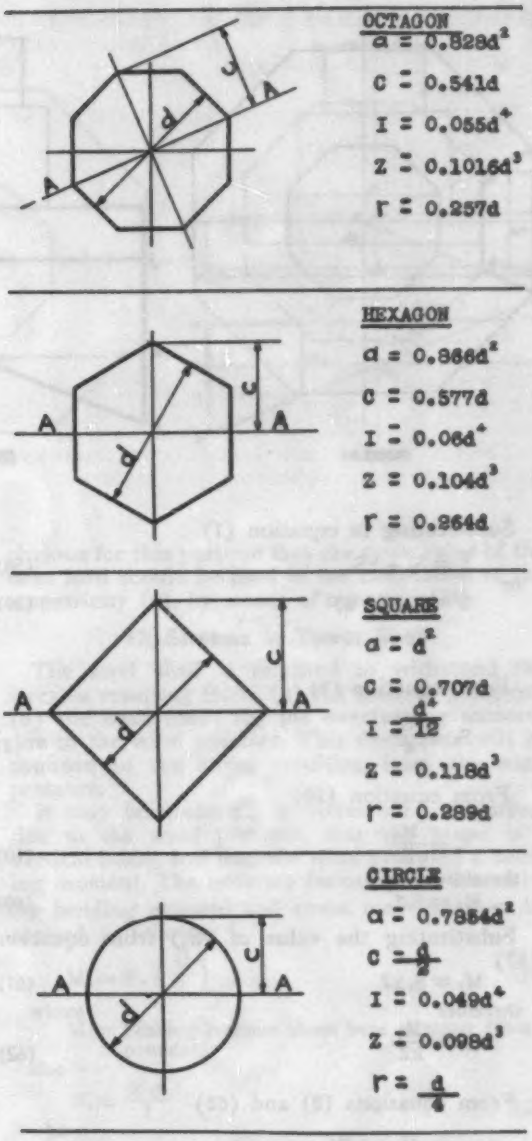


FIGURE 2
Elements of foundation bases
(Axis A-A)

9. Method of Calculating Soil Load From Eccentricity

It is possible to calculate the soil loading (toe pressure) as a function of the eccentricity. This method will be explained in order that it may be compared with the method described in Sections 3, 4 and 5.

Let (k) be a factor by which the dead load pressure must be multiplied to equal the soil loading due to overturning as follows:

$$kS_1 = S_2 \tag{57}$$

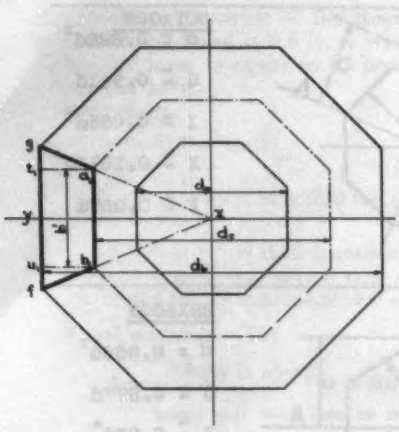


FIGURE 3

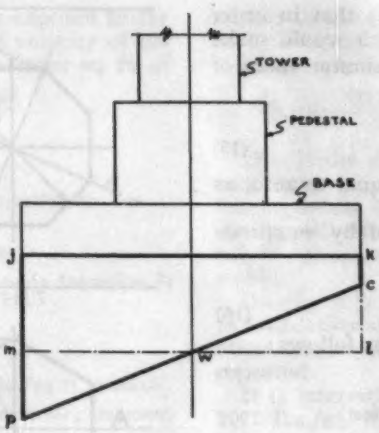


FIGURE 3a

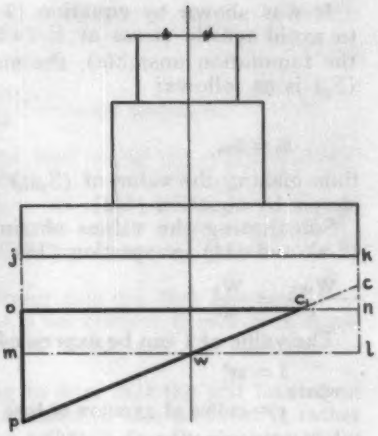


FIGURE 3b

Substituting in equation (1)

$$S = S_1 + kS_1 \quad (58)$$

or

$$S = S_1(1 + k) \quad (59)$$

From equation (2)

$$S_1 = \frac{W}{a} \quad (2)$$

From equation (10)

$$S_2 = \frac{M_f}{Z} \quad (10)$$

therefore

$$M_f = S_2 Z \quad (60)$$

Substituting the value of (S_2) from equation (57)

$$M_f = S_1 kZ \quad (61)$$

therefore

$$S_1 = \frac{M_f}{kZ} \quad (62)$$

From equations (2) and (62)

$$S_1 = \frac{W}{a} = \frac{M_f}{kZ} \quad (63)$$

and

$$M_f = \frac{WkZ}{a} \quad (64)$$

From equation (12)

$$e = \frac{M_f}{W_t} \quad (12)$$

The value of (e) calculated from equation (12) is maximum for any particular foundation, which is the value governing stability. At the present moment we are concerned with the maximum soil loading (toe pressure) which occurs when the dead load is maximum. It is therefore necessary to substitute (W) in place of (W_t) as follows:

$$e = \frac{M_f}{W} \quad (65)$$

Equation (64) can be written

$$\frac{M_f}{W} = \frac{kZ}{a} \quad (66)$$

Since the term $\left(\frac{M_f}{W}\right)$ occurs in both equations (65) and (66), it follows that

$$e = \frac{kZ}{a} \quad (67)$$

and

$$k = \frac{ea}{Z} \quad (68)$$

Substituting this value of (k) in equation (59)

$$S = S_1\left(1 + \frac{ea}{Z}\right) \quad (69)$$

In the case of an octagonal base,

$$a = 0.828\ d^2 \quad (70)$$

$$Z = 0.01016\ d^3 \quad (71)$$

Substituting these values in equation (68)

$$k_{octagon} = \frac{8.15e}{d} \quad (72)$$

Therefore, for an octagonal base, equation (69) may be written:

$$S_{octagon} = S_1\left(1 + \frac{8.15e}{d}\right) \quad (73)$$

For comparison, the maximum soil loading in example No. 1 will be calculated (as example No. 3) on the basis of eccentricity. From previous calculations, it was found that:

$M_f = 200{,}000$ foot pounds
$W = 174{,}200$ pounds

Therefore by equation (65)

$$e = \frac{200{,}000}{174{,}200} = 1.15$$

The maximum soil loading due to the dead load (S_1) was found to be 1155 pounds per square foot, and (d_b) is equal to 13.5 feet.

Substituting in equation (73)

$$S = 1155\left(1 + \frac{8.15 \times 1.15}{13.5}\right)$$

$S = 1155 \times 1.693 = 1955$ pounds per square foot.

This checks the value of 1958 pounds per square foot calculated (by slide rule) in Section 7, thus

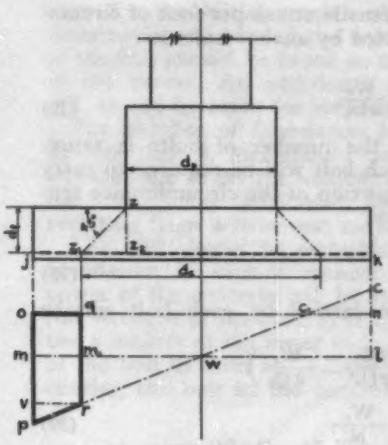


FIGURE 3c

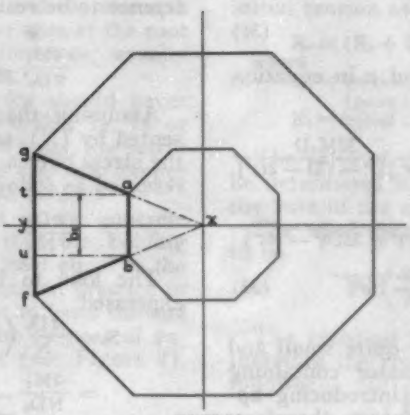


FIGURE 3d

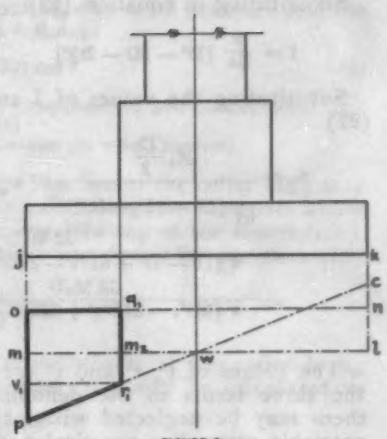


FIGURE 3e

indicating that either method yields the same result.

10. Soil Loading at Any Point

Having calculated the eccentricity, it is a simple matter to determine the unit stress on the soil at any point whose distance from the centroidal axis is (c′).

The unit stress on the soil, from equation (1), is as follows:

$$S = S_1 + S_2 \tag{1}$$

Since the value of (S_2) for points to the right of the axis is negative, the value of (S) will be:

$$S = S_1 - S_2 \text{ (see equation 1-a)} \tag{1-b}$$

Equations (1) and (1-b) can be combined as follows:

$$S = S_1 \pm S_2 \tag{1-c}$$

From equation (2)

$$S_1 = \frac{W}{a} \tag{2}$$

The value of (S_2) can be written:

$$S_2 = \frac{Wec'}{ar^2} \text{ (see equations 14 and 17)} \tag{23}$$

Therefore,

$$S = \frac{W}{a} \pm \frac{Wec'}{ar^2}$$

Simplifying:

$$S = \frac{W}{a}\left(1 \pm \frac{ec'}{r^2}\right) \tag{24}$$

This value of (S) is the total unit stress at any point whose distance (in feet) from the centroidal axis is (c′).

It is important to note that equations (1-a), (14) and (17) referred to above were used to determine the stability and the eccentricity under the poorest condition, which obviously occurs when the dead load is at its minimum. Equation (24) can be used to determine the stress under any dead load, therefore, equation (24) may be based on either (W) or (W_1) depending on the dead load for which the stress is to be determined. It is obvious for this purpose that the same value of the dead load should be used in the calculation of the eccentricity (e), by means of equation (12).

11. Stresses in Tower Shell

The steel shell is required to withstand the stresses resulting from, (a) the internal pressure; (b) the dead load; (c) the overturning moment due to the wind pressure. This discussion will be confined to the stress resulting from the wind pressure.

It may be assumed, in determining the stress due to the wind pressure, that the tower is a vertical beam, and that the wind produces a bending moment. The ordinary formulas for determining bending moment and stress may therefore be applied, as follows:

$$M_t = P_w\left(\frac{H}{2}\right) \tag{26}$$

where

M_t = bending moment about base of tower (foot pounds).

also

$$S_t = \frac{M_t c}{I} \tag{27}$$

where

S_t = unit stress in tower shell due to bending moment (M_t). (lbs./sq. ft.)

Note: The unit stress in the tower shell (S_t) is calculated in pounds per square foot in order to be consistent with the other calculations which are in foot-pound unts. Steel stresses, however, are ordinarily given in pounds per square inch. In order to convert the stress from (pounds/sq. ft.) as calculated, to (pounds/sq. in.) it is necessary to divide (S_t) by 144.

The shell is a hollow cylinder, in which case:

$$c = \frac{D}{2} \tag{28}$$

and

$$I = \frac{\pi}{64}(D^4 - D_1^4) \tag{29}$$

where

D = outside diameter of tower (feet)

D_1 = inside diameter of tower (feet)

when

t = thickness of shell (feet)

and

$$D - D_1 = 2t \tag{30}$$

$$D_1 = D - 2t \tag{31}$$

Substituting in equation (29)

$$I = \frac{\pi}{64}\left[D^4 - (D-2t)^4\right] \tag{31}$$

Substituting the values of I and c in equation (27)

$$S_t = \frac{M_t \frac{D}{2}}{\frac{\pi}{64}\left[D^4 - (D-2t)^4\right]} = \frac{32M_tD}{\pi\left[D^4 - (D-2t)^4\right]}$$

$$= \frac{32\,M_tD}{\pi\left[D^4 - D^4 + 8D^3t - 24D^2t^2 + 32Dt^3 - 16t^4\right]}$$

$$= \frac{32\,M_tD}{\pi\left[8D^3t - 24D^2t^2 + 32Dt^3 - 16t^4\right]} \tag{32}$$

The values of t^2, t^3 and t^4 are quite small and the three terms in the denominator containing them may be neglected without introducing appreciable error. For practical purposes, therefore, equation (32) may be written as follows:

$$S_t = \frac{32M_tD}{8\pi D^3t} \tag{32-a}$$

This equation may be reduced to:

$$S_t = \frac{4M_t}{\pi D^2t} \tag{32-b}$$

The thickness of shell plate required to resist the bending moment only, is therefore

$$t = \frac{4M_t}{\pi D^2S_t} \tag{33}$$

By multiplying the stress in pounds per square foot (S_t) by the shell thickness (t) the stress per foot of circumference is obtained as follows:

$$tS_t = \frac{4M_t}{\pi D^2} \tag{34}$$

12. Foundation Bolts for Self-Supporting Tower

The foundation or anchor bolts for a self-supporting tower are required to resist the overturning moment (M_t) resulting from the wind pressure, after allowance has been made for the resistance offered by the weight of the tower. Obviously the resistance offered by the tower's weight is least effective when the minimum weight is acting. The anchor bolts should therefore be calculated for the condition existing when the tower is empty and without insulation, platforms, etc. This weight will be designated by (W_e).

It was shown that the maximum stress per foot of circumference due to the wind moment can be calculated by equation (34). That equation gives the stress at the circumference of the shell, however, at the present moment it is desired to determine the bolt stress making it necessary to substitute (D_b) in place of (D). The stress per foot of bolt circle circumference can then be written:

$$\frac{4M_t}{\pi D_b^2} \tag{35}$$

where
D_b = diameter of bolt circle (feet).

The compressive stress per foot of circumference due to the weight of the tower is

$$\frac{W_e}{\pi D_b} \tag{36}$$

The maximum tensile stress per foot of circumference to be resisted by anchor bolts is

$$\frac{4M_t}{\pi D_b^2} - \frac{W_e}{\pi D_b} \tag{37}$$

Assuming that the number of bolts is represented by (N), each bolt will be required to carry the stress over a portion of the circumference represented as follows:

$$\frac{\pi D_b}{N} \tag{38}$$

The load to be carried by each bolt can be expressed

$$S_b = \frac{\pi D_b}{N}\left(\frac{4M_t}{\pi D_b^2} - \frac{W_e}{\pi D_b}\right)$$

$$= \frac{4M_t}{ND_b} - \frac{W_e}{N} \tag{39}$$

where
S_b = maximum load on each bolt (pounds).

The nut should always be tight, placing some initial tension on the bolt. Of course due allow-

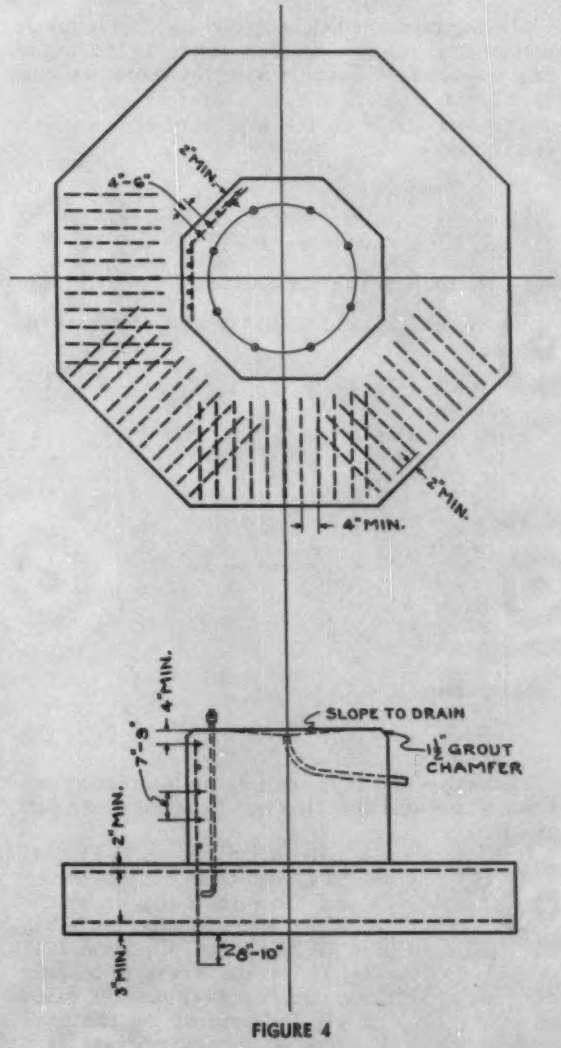


FIGURE 4

ance for the initial tension should be made in determining the size of the bolt, and the strength of the bolt should be based on the area at the root of the thread. An additional allowance, usually ⅛", should be made for corrosion.

The number of foundation bolts should never be less than 8, and should preferably be 12 or more, as the larger the number of bolts, the better the stresses are distributed, and the less danger resulting from a loose nut on one bolt.

The bolt should be embedded in the concrete foundation in such a manner that the holding power of the concrete will be at least equal to the full strength of the bolt. It is common practice to use a washer at the lower end, or to bend the end of the bolt to form an "L" for the purpose of anchoring the bolt in the concrete (see Figure 7).

13. Guyed Towers

In cases where the tower is very high, it is sometimes found desirable to maintain stability by means of guy wires rather than a large foundation. Although it is not uncommon to find two or even three sets of guy wires on one stack, towers seldom have more than one set, and even these cases are rare. This discussion, therefore, will be confined to towers with one set of guy wires.

Four guy wires are usually used for each set, although in some instances three, and in others as many as six have been used. They are attached to a rigid collar which is located at a point approximately 2/3 (sometimes ¾) of the tower height above the foundation.

14. Pull on Guy Wires

The maximum pull on the guy wire occurs when the wind blows along that wire, and each wire must be designed to take care of the entire wind reaction at the collar.

The pull on the guy wire can be expressed as follows:

$$R_g = \frac{R_c}{\sin \theta} \tag{40}$$

or

$$R_g = R_c \csc \theta \tag{41}$$

where

R_g = pull on guy wire due to wind pressure (pounds)
R_c = horizontal wind reaction at collar (pounds)
θ = angle that the guy makes with the vertical (degrees)

The value of the angle θ will usually lie between 30 and 75 degrees.

The vertical component of the pull on the guy wire can be expressed in any of the following ways:

$$R_g \times \cos \theta \tag{42}$$

$$\frac{R_c \times \cos \theta}{\sin \theta} \tag{43}$$

$$R_c \times \cot \theta \tag{44}$$

It is important to note, however, that there is always some initial tension on the guys which must be considered. This initial tension may be assumed to be 5000 lbs./sq. in., which amounts to 1000 lbs. for ½" wires and 250 lbs. for ¼" wires. The weight of the wires may be neglected, when using these figures.

The actual vertical component will be a function of the total pull on the guy wire, which is the sum of the pull due to wind pressure and the initial tension as follows:

$$R_v = (R_g + R_t) \cos \theta \tag{45}$$

where

R_v = vertical component of pull on guy wire (pounds)
R_t = initial tension on wire (pounds).

The value of the reaction at the collar (R_c) may be determined by calculating the moments about the base of the tower (the top of the foundation).

The wind moment was found by equation (26) to be

$$P_w \left(\frac{H}{2}\right)$$

The resisting moment arm at the collar is h_1, therefore the reaction (R_c) may be calculated as follows:

$$R_c = \frac{P_w \left(\frac{H}{2}\right)}{h_1} \tag{47}$$

or

$$R_c = \frac{P_w H}{2 h_1} \tag{48}$$

where

h_1 = height from top of foundation to collar (feet).

15. Foundations for Guyed Towers

It was shown by equation (1) that the total soil loading, to be considered in the design of tower foundations, is the sum of (S_1) which is the dead load, and (S_2) which is the load due to the overturning, or wind moment. In the case of the guyed towers, there is no overturning moment, however, the wind pressure does have an important effect on the foundation, as the soil is required to resist the vertical component of the pull on the guy wires.

For guyed towers, therefore, equation (1) must be revised as follows:

$$S = S_1 + S_g \tag{49}$$

where

S_g = unit soil loading due to the pull on the guy wire. (pounds/sq. ft.)

The value of (S_g) can be determined as follows:

$$S_g = \frac{R_v}{a} \tag{50}$$

From equation (2)

$$S_1 = \frac{W}{a} \tag{2}$$

Substituting in equation (49)

$$S = \frac{W + R_v}{a} \tag{51}$$

16. Foundation Bolts for Guyed Towers

The foundation bolts for guyed towers are required to resist the shearing action of the wind pressure at the base of the tower. It is obvious that ample allowance should be made in the size of the bolts to provide for the initial tension due to tightening the nuts, and also for corrosion.

The shear at the base of the tower, which must be resisted by the bolts, is equal to the horizontal reaction to the wind pressure at that point. This is equal to the difference between the total wind

pressure and the reaction at the collar and can be expressed as follows:

$$R_b = P_w - R_c \qquad (52)$$

where

R_b = horizontal wind reaction, or shear, at the base of the tower. (pounds)

17. Stress in Shell of Guyed Tower

The wind pressure acting on a guyed tower produces a negative bending moment at the collar,

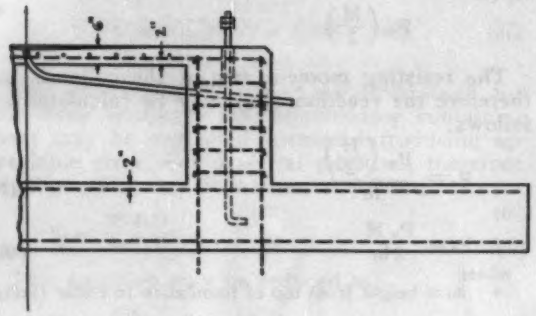


FIGURE 5

and a positive bending moment between the base and the collar. The maximum values of these two moments can be calculated as follows:

$$M_c = -\frac{P_w}{2H}(H - h_1) \qquad (53)$$

$$M_p = P_w H\left(1 - \frac{H}{2h_1}\right) \qquad (54)$$

where

M_c = negative bending moment at collar. (foot pounds)

M_p = maximum positive bending moment between collar and base. (foot pounds).

Having determined the bending moments, the stress in a given shell, or the shell thickness required to resist the bending moment may be calculated by substituting the value of (M_c) or (M_p) in place of (M_t) in equations (32-b) and (33).

18. Piling

In cases where the safe soil loading is very low, it is sometimes found difficult to design an ordinary foundation which will not overload the soil. In such cases it is desirable to support the load on piles rather than on the soil.

Wooden piles are ordinarily used, and they vary greatly in length, depending on the nature of the soil. The diameter at the lower end is about 6″; and the diameter at the top is about 10″ for piles not over 25 feet in length, and 12″ for longer piles.

Wooden piles generally depend on the frictional resistance of the ground for their load carrying capacity, as they have comparatively little strength as columns. The safe load which a pile will support varies greatly in different localities. Building laws sometimes govern the pile loading, and in such cases, the load is usualy about 20 tons per pile, although occasionally 25 tons is permissible.

When conditions are not definitely known, however, the only safe procedure is to drive a few piles for test purposes. The common method of calculating the safe load is by means of what is known as the "Engineering News Formula," which has been widely published. There are really two formulas; one for piles driven with a drop hammer, and another for piles driven with a steam hammer, as follows:

For drop hammer

$$P = \frac{2W_h f}{p_h + 1.0} \qquad (55)$$

For steam hammer

$$P = \frac{2W_h f}{p_h + 0.1} \qquad (56)$$

where

P = safe load which each pile will support. (pounds)

W_h = weight of hammer. (pounds)

f = height of hammer fall. (feet)

p_h = penetration or sinking under the last blow, on sound wood. (inches)

Care should be exercised in driving piles, to assure that they are deep enough to develop their full strength, but they should not be driven too much, as this practice results in splitting or breaking, and greatly reduces the load carrying capacity.

Although piles have been driven with a center to center spacing as small as 2′ 6″, it is strongly recommended that this distance be not less than 3′ 0″. Closer spacing disturbs the ground sufficiently to greatly reduce or destroy the frictional resistance.

The top of the piles should always be cut off below the water level, otherwise they will decay rapidly.

The reinforced concrete cap is constructed on top of the piles in such a manner that the piles extend about 6″ into the concrete (see Figure 6).

19. Stresses in Foundation

After having selected a foundation of such size and shape as to fulfill the requirements of the problem from the standpoint of stability and soil loading, it becomes necessary to calculate the stresses in the foundation itself, to see that they do not exceed the allowable limits.

The first step in this procedure is to determine

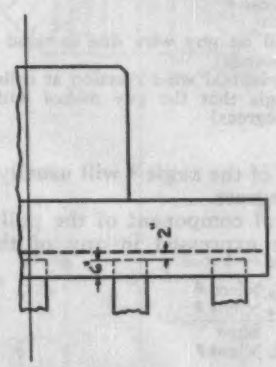


FIGURE 6

the loading, which consists primarily of the upward reaction of the soil. Figure 3 represents the plan view of a typical (octagonal) foundation, and Figure 3a shows the loading diagram. In this diagram the dead load (S_1) is represented by the rectangle (jklm). The wind load (S_2), which is positive on one side of the centerline, is indicated by the triangle (mpw). On the opposite side of

the centerline the wind load is negative, thereby counteracting a portion of the dead load (wlc). The actual soil loading will therefore be represented by the area (jkcp). However, the weight of the base, and of the earth fill above the base (area jkno Figure 3b) do not exert any upward force on the foundation, and may therefore be deducted from the total load, for the present purpose. The *effective* upward reaction will then be the area ($oc_1 p$) in Figure 3b.

19a. Diagonal Tension

The vertical shear, resulting from the upward reaction of the soil, produces diagonal tension stresses in the foundation. The critical section lies at a distance from the face of the pedestal equal to the effective depth of the base, as indicated by point (Z_1) in Figure 3c. In other words, the foundation tends to break along line (ZZ_1). The vertical shear to be resisted is equal to the net soil pressure on the part of the foundation outside the critical section.

For design purposes, therefore, the load will be the area (oqrp), (Figure 3c) applied over the area (a_1 b_1 fg), (Figure 3). Because of the irregular shape of the load diagram, its magnitude can be more conveniently calculated by breaking it up into its component parts, the total load (V_s) being the sum of the individual loads, as follows:

Shape of part	Outline in plan (Fig. 3)	Outline in elevation (Fig. 3c)
Rectangular Prism	a_1 b_1 u_1 t_1	oqrv
Wedge	a_1 t_1 g	oqrv
Wedge	b_1 fu_1	oqrv
Wedge	a_1 b_1 u_1 t_1	rvp
Pyramid	a_1 t_1 g	rvp
Pyramid	b_1 fu_1	rvp

The unit stress (diagonal tension) resulting from this vertical shear load can be determined as follows:

$$f_d = \frac{V_s}{b' j d_r} \qquad (80)$$

where

f_d = unit stress in concrete (in diagonal tension) due to vertical shear load. (pounds/sq. in.)
V_s = vertical shear load, outside the critical section (see Figures 3 and 3c). (pounds)
b' = width of critical section which serves to resist diagonal tension stresses (line a_1 b_1 Figure 3). (inches)
j = ratio of lever arm of resisting couple to depth (d_r) (see Table 2).
d_r = effective depth of base measured from top of base to centerline of reinforcing steel. (inches)

Example No. 4. Check diagonal tension stresses in the foundation considered in example No. 1:

Figure unit soil loading due to weight of base and earth (see Section 7):

Concrete base	63,000 lbs.	
Earth fill	32,700 lbs.	
Total	95,700 lbs.	
Unit soil loading	$= \frac{95{,}700 \text{ lbs.}}{151 \text{ sq. ft.}}$	$=$ 633 lbs./sq. ft.

Total unit dead load (S_1) (jm, figure 3c) = 1,155 lbs./sq. ft.
Unit dead load due to weight of base and earth fill (jo) = 633
Net soil load (om) = 522 lbs./sq. ft.
Maximum unit wind load (S_s), (mp) = 803
Maximum effective unit shear load (op) 1,325 lbs./sq. ft.

Line $(mw) = \frac{162}{2} = 81''$

$d_p = 72''$. $d_r = 21''$. $d_b = 162''$
$d_s = 72 + 21 + 21 = 114''$
Line $(gf) = 67.1''$ (see Table 1).
Line $(m_1 w) = \frac{114}{2} = 57''$.
Line $(a_1 b_1) = \frac{67.1 \times 57}{81} = 47.2'' = (b')$.
Line $(gt_1) = \frac{67.1 - 47.2}{2} = 9.95''$
Line $(a_1 t_1) = \frac{162 - 114}{2} = 24''$

Factor $j = .87$ (see Table 2).
Load $(m_1 r) = \frac{803 \times 57}{81} = 565$ lbs./sq. ft.
Load $(qr) = 565 + 522 = 1{,}087$ lbs./sq. ft.

Calculate shear load (V_s)

$47.2'' \times 24'' \times \frac{1{,}087 \text{ lbs./sq. ft.}}{144 \text{ sq. in.}}$	$=$ 8,550 lbs.
$9.95'' \times 24'' \times \frac{1{,}087}{144}$	$=$ 1,805
$47.2 \times 24 \times \frac{238}{2 \times 144}$	$=$ 935
$\frac{9.95 \times 238 \times 24 \times 2}{3 \times 144}$	$=$ 263
Total (V_s)	$=$ 11,558 lbs.

Calculate unit stress in concrete (equation 80)

$$f_d = \frac{11{,}558}{47.2 \times .87 \times 21} = 13.4 \text{ lbs./sq. in.}$$

This stress is satisfactory, as 40 lbs./sq. in. would be allowed (see Table 2).

19b. Depth of Slab Required for Punching Shear

The thickness of the foundation slab (bottom course) must also be sufficient to withstand the tendency to shear along line (Z-Z_2), (Figure 3c) at the edge of the pedestal. This shearing load may be determined as follows:

$$S_s = S_1 + S_o \qquad (81)$$

The stresses in this case are not distributed over the foundation area, but are concentrated at the edge of the pedestal.

Then

S_s = total maximum unit shearing load. (lbs. per lineal foot of pedestal perimeter).
S_1 = unit shearing load due to dead load. (lbs. per lineal foot of pedestal perimeter).
S_o = maximum unit shearing load due to overturning moment. (lbs. per lineal foot of pedestal perimeter).

The value of (S_4) can be determined by adding the weight supported by the pedestal to the weight of the pedestal itself, subtracting the load-carrying value of the soil directly under the pedestal, and dividing the difference by the perimeter of the pedestal base as follows:

$$S_4 = \frac{W_s + W_s + W_p - (a_p S_{s11})}{L_p} \qquad (82)$$

where

W_p = weight of foundation pedestal (top course). (pounds)
a_p = plan area of foundation pedestal. (sq. ft.)
S_{s11} = maximum allowable unit soil loading. (pounds/sq. ft.)
L_p = perimeter of foundation pedestal. (feet)

Obviously, if the value of (a_p S_{s11}) is equal to

or greater than $(W_s + W_a + W_p)$, the value of (S_4) becomes zero, and (S_3) will then be equal to (S_5).

The value of (S_3) can be determined in a manner somewhat similar to that proposed in Section 12. In that section the overturning load was calculated as a function of the periphery of the foundation bolt circle, by means of equations (27) and (35). The bolt circle was assumed to be a hollow cylinder, the wall thickness being infinitely small, as compared with the diameter.

In the determination of the shear at the edge of the foundation pedestal, a similar procedure may be followed, substituting (M_f) in place of (M_t), and appropriate values of (I) and (c) in equation (27), depending on the shape of the pedestal.

Reduced to their simplest forms, the equations for the ordinary foundation shapes are as follows:

Octagon

$$S_s = \frac{M_f}{.814 d_p^3} \tag{83}$$

Hexagon

$$S_s = \frac{M_f}{.832 d_p^3} \tag{83a}$$

Square

$$S_s = \frac{M_f}{.943 d_p^3} \tag{83b}$$

Circle

$$S_s = \frac{M_f}{.785 d_p^3} \tag{83c}$$

In these equations (d_p) is the short diameter of the pedestal (feet).

Once the shearing load (S_s) per foot of pedestal perimeter is known, it is a simple matter to calculate the unit stress in the concrete, by dividing (S_s) by the effective depth of the base, as follows:

$$f_p = \frac{S_s}{12 d_f} \tag{84}$$

where

f_p = unit stress in concrete base due to punching shear. (pounds/sq. in.)

Note: The factor 12 is introduced for the purpose of converting (S_s) from (pounds/lin. foot) to (pounds/lin. inch) as unit stress (f_p) is in terms of (pounds/sq. in.).

Example No. 5. To illustrate the procedure, the punching shear will be calculated for the foundation considered in example No. 1.

Calculate dead load shear (S_4) by equation (82)

$W_s = 30{,}000$ lbs. $\quad W_a = 48{,}500$ lbs.

$W_p = 119.2$ cu. ft. $\times$ 150 lbs. $= 17{,}850$ lbs.

$a_p = 29.8$ sq. ft. $\quad S_{all} = 2{,}000$ lbs./sq. ft.

$L_p = 2.484 \times 8 = 19.87$ ft.

$$S_4 = \frac{30{,}000 + 48{,}500 + 17{,}850 - (29.8 \times 2{,}000)}{19.87}$$

$= 1{,}850$ lbs./lin. foot.

Calculate shearing stress due to overturning moment (S_3) by equation (83)

$M_f = 200{,}000$ foot pounds (see section 7).

$d_p^3 = 6^3 = 36.$

$$S_3 = \frac{200{,}000}{.814 \times 36} = 6{,}820 \text{ pounds/lin. foot}$$

$S_s = 1{,}850 + 6{,}820 = 8{,}670$ pounds/lin. foot. (81)

$d_f = 21''$

$$f_p = \frac{8{,}670}{12 \times 21} = 34.4 \text{ pounds/sq. in.} \tag{84}$$

This stress is satisfactory, as 120 pounds/sq. in. is permissible. (See Table 2.)

In the case of guyed towers, or stacks, the shear load due to overturning moment (S_3) does not apply, but is replaced by

$$\left(R_g / L_p\right)$$

which is the load due to the pull on the guy wires, as follows:

$$S_{s(guyed)} = S_4 + \frac{R_g}{L_p} \tag{81a}$$

19c. Reinforcement of Base for Upward Bending Reaction of Soil

In designing the base of the foundation to resist the bending moment due to the upward reaction of the soil, the critical section is located at line (ab), (Figure 3d) along one face of the pedestal (top course). The moments are therefore figured about line (ab), on the basis of the load on the trapezoid (abfg). The load which serves to produce the bending moment in the base is the "unbalanced" upward reaction. Since the weight of the base, and the weight of the earth fill above the base do not contribute to the bending moment, they may be deducted from the total load when calculating the bending moment. The effective loading will therefore be represented by the area (o q_1 r_1 p) Figure 3e.

The load is assumed to be applied at its center of gravity, and the moment figured about line (ab). Due to the irregular shape of the load diagram, it is difficult to locate the center of gravity, and it is therefore more convenient to break it up into its component parts (prisms, wedges, pyramids, etc.), and figure the moment of each part separately. Obviously, the total moment (M_b) will be the sum of the individual moments.

In the case of the rectangular prism, the lever arm used in figuring its moment will be one half of the distance from point (a) to point (t), (Figure 3d). In the case of the wedges and pyramids, the lever arm will be two-thirds of the distance from point (a) to point (t).

The individual components and their respective lever arms are as follows:

	Outline in plan, Fig. 3d	Outline in elevation, Fig. 3c	Lever Arm
Rectangular Prism	abut	q_1 r_1 v_1 o	$\frac{\text{Distance (at)}}{2}$
Wedge	atg	q_1 r_1 v_1 o	$\frac{\text{Distance (at)} \times 2}{3}$
Wedge	bfu	q_1 r_1 v_1 o	$\frac{\text{Distance (at)} \times 2}{3}$
Wedge	abut	r_1 v_1 p	$\frac{\text{Distance (at)} \times 2}{3}$
Pyramid	atg	r_1 v_1 p	$\frac{\text{Distance (at)} \times 2}{3}$
Pyramid	bfu	r_1 v_1 p	$\frac{\text{Distance (at)} \times 2}{3}$

In calculating the amount of reinforcement required, it is assumed that the portion of the base designated (abut), (Figure 3d) acts as a cantilever beam (of rectangular cross-section) having a width equal to one face of the pedestal (ab), a depth equal to the effective depth of the base (d_f) and a length equal to (at).

Having calculated the bending moment as proposed above, the next step is to check the depth

of the base, and determine the amount of reinforcing steel required. These calculations are based on the commonly accepted formulas for reinforced concrete. (It should be noted that for this purpose it is more convenient to figure the moments in terms of inch-pounds, as the stresses in concrete and steel are usually given as pounds per square inch, whereas in figuring soil loading foot-pound units are used, as soil loading is usually stated as pounds per square foot.)

For *balanced design*, that is, conditions in which both concrete and steel are stressed to their full allowable capacity, the required depth (d_f) of the base may be determined as follows:

$$d_f = \sqrt{\frac{M_b}{f_s\, p_r\, j b_s}} \qquad (85)$$

where

d_f = depth of base, measured from top of concrete to centerline of reinforcing steel. (inches)
M_b = bending moment in base. (inch-pounds)
f_s = safe working stress, reinforcing steel in tension. (pounds per sq. in.)
$p_r = \left(A_s / b_s\, d_f \right)$ = ratio of effective area of reinforcing steel to effective area of concrete.
j = ratio of lever arm of resisting couple to depth (d_f).
b_s = width of beam (line ab, Figure 3d). (inches)
A_s = effective cross sectional area of steel reinforcement in tension. (square inches)

If the design is balanced, that is, the actual depth of the base (d_f) is that calculated by equation (85), the value of (A_s) may be determined as follows:

$$A_s = b_s\, d_f\, p_r \qquad (86)$$

If the depth (d_f) is greater than required by equation (85), in which case the steel is stressed to its full capacity but the concrete is understressed, the value of (A_s) becomes:

$$A_s = \frac{M_b}{f_s\, j d_f} \qquad (87)$$

If the depth (d_f) is less than required by equation (85), it is recommended that the dimensions of the base be changed to give the required depth. In case circumstances make it impossible to increase (d_f) to the required dimension, it will be necessary to increase the amount of reinforcement used. The determination of the amount of reinforcement required for such special cases is beyond the scope of this article, and reference is made to the various publications dealing specifically with concrete design for further details.

Having calculated the cross sectional area of steel required, a selection is made as to the diameter, shape, number and spacing of bars which will give the required area. It is recommended that the center-to-center distance be about 4 inches if possible, but not less than 2½ times the bar diameter for round bars, or 3 times the side dimension for square bars. Generally speaking, a large number of small bars (½, ⅝, or ¾ inch) are preferable to a smaller number of larger bars.

It should be borne in mind that the area of reinforcement determined above is the amount required for that portion of the foundation having a width equal to (ab), Figure 3d, which was assumed to be the cantilever beam carrying the entire bending load. This amount of reinforcement should therefore be placed within the limits of the beam width (ab). However, additional reinforcement should be installed to reinforce the base between the points (gt), and also at (uf), using the same type and spacing of bars as determined for the beam section (ab). This additional reinforcement insures that the entire area of the base is reinforced and weak spots eliminated.

Obviously, the reinforcing bars should extend entirely across the base. Also, there should be a set of reinforcing bars parallel to each of the axes, i.e., four sets of bars for an octagonal base, three sets for a hexagon, etc., thus providing strength in all directions.

There should be at least 3 inches of concrete below the reinforcing bars at the bottom of the base. Reinforcement in other parts of the foundation should be covered with not less than 2 inches of concrete.

Example No. 6. Determine bottom reinforcement for the foundation referred to in example No. 1.

Figure bending loads

$$\text{Line } (m_s\, w) = \frac{72''}{2} = 36''$$

$$\text{Load } (m_s\, r_s) = \frac{803 \times 36}{81} = 357 \text{ pounds/sq. ft.}$$

$$\text{Load } (q_s\, r_s) = 357 + 522 = 879 \text{ pounds/sq. ft.}$$

$$\text{Load } (v_s\, p) = 803 - 357 = 446 \text{ pounds/sq. ft.}$$

Figure moment (M_b)

$$\text{Line (ab)} = 29.8''$$
$$\text{Line (ta)} = 45''$$
$$\text{Line (gt)} = 18.65''$$

$$\frac{29.8'' \times 45''}{144 \text{ sq. in.}} \times 879 \text{ pounds/sq. ft.} \times \frac{45''}{2} = 184{,}000 \text{ in.-lbs}$$

$$\frac{18.65 \times 45}{144} \times 879 \times \frac{45 \times 2}{3} = 153{,}000$$

$$\frac{29.8 \times 45}{144} \times \frac{446}{2} \times \frac{45 \times 2}{3} = 62{,}300$$

$$\frac{18.65 \times 446 \times 45}{144 \times 3} \times 2 \times \frac{45 \times 2}{3} = 51{,}900$$

$$\text{Total } (M_b) = 451{,}200 \text{ in.-lbs.}$$

Check depth of base for balanced design (equation (85)

$f_s = 18{,}000$
$p_r = .0089$
$j = .87$
$b_s = 29.8''$
$f_s\, p_r\, j = 138.7$

$$d_{f\,(\text{balanced})} = \sqrt{\frac{451{,}200}{138.7 \times 29.8}} = 10.5''$$

Since the actual depth is 21 inches, whereas only 10.5 inches would be required, the concrete will be understressed, and the area of reinforcing steel should be calculated by equation (87).

$$A_s = \frac{451{,}200}{18{,}000 \times .87 \times 21} = 1.37 \text{ sq. in.}$$

Use ½ inch deformed square bars (.25 sq. in. area).

Number required $\frac{1.37}{.25} = 5.5$. Use 6 bars within the width of beam (ab).

Spacing $\frac{29.8''}{6} = 4.96''$. Use 5-inch spacing entirely across side (gf), which will require $\frac{67.1''}{5}$ = 13 bars per set. Four sets of bottom reinforcing bars will be required for the octagonal foundation.

19d. Reinforcement to Resist Stresses Due to Uplift

As explained previously, the wind moment creates a positive soil load on one side of the centerline, and a negative load on the opposite side. In other words, the action of the wind tends to lift the foundation on the negative side. This upward force, or "uplift" effect, is resisted by the weight of the concrete base itself, and by the weight of the earth fill on top of the base. It therefore becomes necessary to reinforce the top of the base, to resist the resulting negative bending moment.

The procedure is quite similar to that described for the upward soil reaction (Section 19c). The load acts on the area (abfg), and the outline of the theoretical beam carrying the load is (abut) as in Section 19c. However, in this case the load is the weight per square foot of concrete base, plus the weight per square foot of the earth fill, and is uniformly distributed, thus simplifying the calculations. After figuring the moments, the reinforcement is determined in exactly the same manner as explained in Section 19c, using the equation

$$A_s = \frac{M_u}{f_s\, jd_f} \qquad (87a)$$

In this case, (d_f) is the depth of the base from the centerline of the upper layer of reinforcement to the bottom of the base, and (M_u) is the bending moment due to the uplift forces (inch-pounds).

Example No. 7. Determine top reinforcement to resist uplift in the foundation referred to in example No. 1.

Weight of concrete 150 lbs./cu. ft. × 2 ft.	= 300 lbs./sq. ft.
Weight of earth 90 lbs./cu. ft. × 3 ft.	= 270 lbs./sq. ft.
Total	= 570 lbs./sq. ft.

TABLE 2
Constants Applying to Foundation Design

	Mixture: Cement / Sand / Coarse Aggregate	1 / 2 / 4	1 / 2 / 5
f_b	Safe bearing load on concrete (lbs./sq. in.)	500	375
f'_c	Ultimate compressive strength (lbs./sq. in.)	2,000	1,500
f_c	Safe unit stress in extreme fiber of concrete (in compression)—(lbs./sq. in.)	800	600
f_d	Safe unit stress in concrete due to vertical shear (diagonal tension) (lbs./sq. in.)	40	30
f_p	Safe unit stress in concrete base due to punching shear. (lbs./sq. in.)	120	90
f_s	Safe working stress, steel reinforcement in tension. (lbs./sq. in.)	18,000	18,000
$(f_s\, j)$	(inch-pounds)	15,600	16,000
$(f_s\, j p_c)$	(inch-pounds)	138.7	88.9
j	Ratio, lever arm of resisting couple to depth (d_f)	.87	.89
$\left[n = E_s/E_c\right]$	Ratio, modulus of elasticity of steel to that of concrete	15	15
$\left[p_c = A_s/b_c d_f\right]$	Ratio, effective area of tension reinforcement to effective area of concrete	.0089	.0056
u*	Safe bond stress (concrete to steel reinforcement) per unit of area of surface of bar. (pounds)		
	Plain bars	60	45
	Deformed bars	75	56

* These figures may be slightly increased by making "U"—bends on the ends of the reinforcing bars.

Note:—The 1:2:4 mixture is recommended as most satisfactory for foundations of the type. The constants for the 1:2:5 mixture are presented as a matter of interest.

Moment

$$\frac{29.8 \times 45}{144} \times 570 \times \frac{45}{2} = 119{,}000 \text{ in.-lbs.}$$

$$\frac{18.65 \times 45}{144} \times 570 \times \frac{45 \times 2}{3} = 99{,}500$$

Total (M_u) = 218,500 in.-lbs.

From equation (87a)

$$A_s = \frac{218{,}500 \text{ inch lbs.}}{18{,}000 \times .87 \times 22} = .636 \text{ sq. in. within beam width (29.8")}$$

Use ½-inch deformed square bars, at 10-inch centers.

19e. Bond

In order for the reinforcement to be effective, the strength of the bond between concrete and steel must be sufficient to permit the reinforcement to develop its full strength. The bond stress may be calculated by means of the following formula:

$$u = \frac{V_u}{\Sigma_o\, jd_f} \qquad (88)$$

where

u = bond stress per unit of area of surface of bar. (pounds)

Σ_o = sum of perimeters of bars within the limits of the beam width (ab). (inches)

Example No. 8. Check bond stresses in example No. 1.

Bottom reinforcement

V_u = 11,578 lbs. (See example No. 4)

$\Sigma_o = 6 \times .5 \times 4 = 12"$

By equation (88)

$$u = \frac{11{,}578}{12 \times .87 \times 21} = 53 \text{ lbs.}$$

Bond stress for bottom reinforcement is satisfactory, as 75 pounds is permissible (see Table 2).

Top reinforcement

Figure shear

$$\frac{47.2" \times 24"}{144} \times 570 \text{ lbs.} = 4{,}480 \text{ lbs.}$$

$$\frac{9.95 \times 24}{144} \times 570 = 947$$

Total (V_u) = 5,427 lbs.

$\Sigma_o = 3 \times .5 \times 4 = 6$

$$u = \frac{5427}{6 \times .87 \times 22} = 48 \text{ lbs.} \qquad (88)$$

The bond stress in top reinforcement is satisfactory, as 75 pounds would be allowed.

19f. Bearing Stresses

The bearing stresses (where the steel tower rests on the concrete pedestal) seldom cause any difficulty, but should be checked as a safety precaution. The bearing stresses consist of the stress due to wind pressure, plus the stress due to the dead load as follows:

$$\text{Bearing stress} = \frac{4M_t}{\pi D_t^2} + \frac{W_s}{\pi D_t} \qquad (37a)$$

(See Sections 11 and 12.)

Equation (37a) gives the bearing stress in pounds per lineal foot of shell circumference. These stresses are spread over the area of the base ring, therfore for practical purposes the unit bearing stress can be determined as follows:

$$f_b = \frac{\frac{4M_t}{\pi D_i^2} + \frac{W_s}{\pi D_i}}{12r_w} \qquad (37b)$$

in which

r_w = width of the tower base ring. (inches)
f_b = unit compression stress on concrete. (pounds/sq. in.)

Equation (37b) may be modified slightly, depending on the exact shape and arrangement of the base ring (or base plate), but in the majority of cases it may be used in the above form with reasonable accuracy.

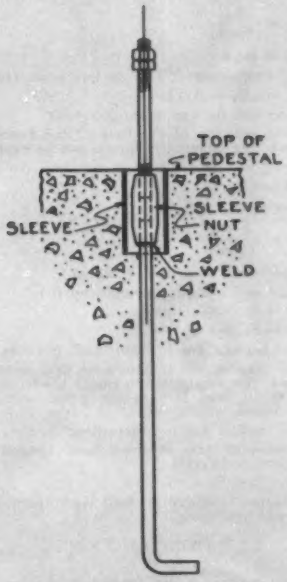


FIGURE 7

For guyed towers, equation (37b) becomes:

$$f_{b\,(guyed)} = \frac{\frac{4M_t}{\pi D_i^2} + \frac{R_v}{\pi D_i}}{12r_w} \qquad (37c)$$

19g. Allowable Stresses in Foundation

It is to be noted that in actual practice the depth of the base in the examples given above could be reduced, if desired. All of the stresses for diagonal tension, punching shear, bending (upward and downward) and bond in the reinforcement are well below the allowable values. As the examples in this case are given for illustration only, the design has not been changed to take maximum advantage of the allowable stresses.

The stresses in foundations of this type should not exceed those commonly accepted as good engineering practice in reinforced-concrete design, for the particular mixture of concrete used. As a matter of convenience Table 2 is presented to show allowable stresses and miscellaneous constants applying to two grades of concrete quite generally used for foundations. It is strongly recommended that the 1:2:4 mixture be used in practice, the figures for the 1:2:5 mixture being shown primarily as a matter of interest.

19h. Suggestions and Recommendations

The calculations explained above provide for reinforcement to resist the stresses due to the various types of loading. It is good practice, however, to install additional steel as a means of tying the foundation together, to form an integral unit. The same size bars are used for this purpose as for the main slab reinforcement, and the designer must use his own judgment as to the number and location of the bars. Figure 4 represents what is considered good practice, and is offered as a guide.

In the case of very large foundations, considerable concrete and weight may be saved by constructing the pedestal with a hollow center, as illustrated in Figure 5. Of course, the inside form is left in place. It should be noted that the base slab extends all the way across, to provide protection and bond for the reinforcing bars.

Foundations supported on piles should be so constructed as to allow the tops of the piles to extend about 6 inches into the base, with the bottom reinforcement about 2 inches above the piles. (See Figure 6.)

Considerable inconvenience is sometimes encountered in setting the tower in place, due to the difficulty of lowering the heavy vessel over the foundation bolts without bending some of them or damaging the threads. Figure 7 illustrates a method of overcoming this difficulty. A sleeve nut is welded to the top of the bolt, and so placed that the top of the nut lies slightly below the surface of the concrete, with a sheet metal sleeve around it. The tower may then be placed in position without interference from the bolts. Stud bolts are next inserted through the lugs on the tower, and screwed into sleeve nuts from the top.

Nomenclature

A_s = effective cross sectional area of steel reinforcement in tension (square inches)

For balanced design

$$A_s = b_s\, d_f\, p_T \qquad (86)$$

If depth (d_f) is greater than required by equation (85)

$$A_s = \frac{M_b}{f_s\, jd_f} \qquad (87)$$

For top reinforcement of slab to resist uplift stresses:

$$A_s = \frac{M_o}{f_s\, jd_f} \qquad (87a)$$

a = area of base of foundation (sq. ft.)

a_p = plan area of foundation pedestal (sq. ft.)

B = barometric pressure (inches H_g)

b_s = width of the critical section (equal to the width of the face of the pedestal) assumed to act as a cantilever beam resisting the bending stresses (line ab, Figure 3d) (inches)

b' = width of critical section which serves to resist the diagonal tension stresses. (line $a_1 b_1$, Figure 3.) (inches)

c = distance from neutral axis of foundation base to point of maximum stress. (feet)

c' = distance from centroidal axis of foundation base to any point under consideration. (feet)

D = outside diameter of tower. (feet)

D_i = inside diameter of tower. (feet)

D_o = tower diameter measured over insulation. (feet)

D_b = diameter of foundation bolt circle. (feet)

d_b = short diameter of foundation base. (feet)

d_c = short diameter of critical section for diagonal tension stresses (see Figures 3 and 3c). (inches)

d_f = effective depth of base of foundation, measured from top of base to centerline of reinforcing steel. (inches)

d_p = short diameter of foundation pedestal. (feet)
E_c = modulus of elasticity of concrete.
E_s = modulus of elasticity of reinforcing steel.

e = eccentricity. (feet)
This factor is the distance from the centroidal axis of the foundation to the point at which the resultant of the dead load and the wind load intersects the base of the foundation. The eccentricity can be calculated as follows:

$$e = \frac{M_f}{W_t} \tag{12}$$

Equation (12) gives the eccentricity at the condition of poorest stability, that is, with the minimum dead load. This is the value which ordinarily is used for design purposes, however, it is obvious that the eccentricity for maximum dead load conditions can be calculated by substituting the value of (W) in equation (12) in place of (W_t). The *maximum* value which it is possible for (e) to have and still maintain the stability of the foundation is

$$e_{max} = \frac{r^2}{c}, \text{ or} \tag{19}$$

$$e_{max} = \frac{Z}{a} \tag{19a}$$

Values of (e_{max}) for various foundation shapes are as follows:

Octagon: $e_{max} = 0.122d$ (22)
Hexagon: $e_{max} = 0.121d$ (22a)
Square: $e_{max} = 0.118d$ (22b)
Circle: $e_{max} = \frac{d}{8}$ (22c)

The value of (e) as calculated by equation (12), and based on the minimum dead load (W_t) should *never* exceed the value calculated by equations (19) or (19a).

F = barometric pressure. (inches H_g)
f = height of hammer fall. (feet)
f_b = unit bearing stress on concrete. (pounds/sq. in.). (See equations 37b and 37c)
f_c = safe unit stress in extreme fiber of concrete (in compression). (pounds/sq. in.)
f_c' = ultimate compressive strength of concrete. (pounds/sq. in.)
f_d = unit stress in concrete (in diagonal tension) due to vertical shear load. (pounds/sq. in.)
f_p = unit stress in concrete base due to punching shear. (pounds/sq. in.)

$$f_p = \frac{S_3}{12d_f} \tag{84}$$

f_s = safe working stress, steel reinforcement in tension. (pounds/sq. in.)
H = height of tower. (feet)
h_f = height of foundation. (feet)
h_1 = height of collar (to which the guy wires are attached) above foundation. (feet)
I = moment of inertia of the base of the foundation. (based on dimensions in feet)
j = ratio of lever arm of resisting couple to depth d_f. (See table 2)
k = factor by which the soil loading due to dead load must be multiplied to equal the soil loading due to overturning, as follows:

$$kS_1 = S_2, \text{ also} \tag{57}$$

$$k = \frac{ea}{Z} \tag{68}$$

Values of k for various foundation shapes are as follows:

Octagon: $k = \frac{8.15e}{d}$ (72)
Hexagon: $k = \frac{8.32e}{d}$ (72a)
Square: $k = \frac{8.47e}{d}$ (72b)
Circle: $k = \frac{8.01e}{d}$ (72c)

L = lever arm of wind load (feet) to be calculated as follows:

$$L = h_f + \frac{H}{2} \tag{9}$$

L_p = perimeter of foundation pedestal. (feet)
M_b = bending moment in base. (inch-pounds)
M_c = negative bending moment at collar. (foot-pounds) (see equation 53)
M_f = overturning moment about base of foundation. (foot-pounds)

$$M_f = P_w L \tag{7}$$

M_p = maximum positive bending moment between collar and base. (foot pounds) (see equation 54)
M_t = bending moment about base of tower. (foot-pounds)

$$M_t = P_w \left(\frac{H}{2}\right) \tag{26}$$

M_u = bending moment in base, due to uplift forces. (inch-pounds)
N = number of foundation bolts
n = (E_s/E_c) = ratio, modulus of elasticity of steel to that of concrete.
P = safe load which each pile will support. (pounds)

P_w = total wind load (pounds) to be calculated as follows:

$$P_w = p_e \; D_e \; H \tag{8}$$

p = wind pressure on a flat surface. (pounds per sq. ft.)
p_e = wind pressure on projected area of a cylindrical tower. (pounds per sq. ft.)
p_h = penetration or sinking of pile under the last hammer blow, on sound wood. (inches)
p_r = ratio, effective area of reinforcing steel to effective area of concrete.

$$p_r = \left(A_s / b_s \, d_f\right)$$

R_b = horizontal wind reaction or shear at base of tower. (pounds)
R_c = horizontal wind reaction at collar. (pounds)
R_g = pull on guy wire due to wind pressure. (pounds)

$$R_g = \frac{R_c}{\sin \theta} \text{ or,} \tag{40}$$

$$R_g = \csc \theta \tag{41}$$

R_v = vertical component of pull on guy wire. (pounds)

$$R_v = (R_g + R_t) \cos \theta \tag{45}$$

R_t = initial tension on guy wire. (pounds)
r = radius of gyration of the base of the foundation (feet). Its relation to the moment of inertia can be expressed as follows:

$$I = ar^2 \tag{17}$$

rearranging:

$$r = \sqrt{\frac{I}{a}} \tag{25}$$

r_w = width of tower base ring. (inches)
S = total unit soil loading. (pounds/sq. ft.)

$$S = S_1 + S_2 \quad \text{also,} \tag{1}$$

$$S = S_1 (1 + k) \tag{59}$$

S_1 = unit soil loading due to dead load. (pounds/sq. ft.)
S_{1m} = unit soil loading due to minimum dead load (pounds/sq. ft.) to include the weight of the empty tower, the foundation and the earth fill only. It does not include insulation, platforms, piping, liquid, etc.
S_2 = unit soil loading due to overturning moment. (pounds/sq. ft.)
S_3 = total maximum unit shearing load. (pounds per lineal foot of pedestal perimeter)

$$S_3 = S_4 + S_5 \tag{81}$$

S_4 = unit shearing load due to dead load. (pounds per lineal foot of pedestal perimeter)

$$S_4 = \frac{W_a + W_s + W_p - (a_p \, S_{all})}{L_p} \tag{82}$$

S_5 = maximum unit shearing load due to overturning moment. (pounds/lineal foot of pedestal perimeter).
For pedestals of various shapes, the values of (S_5) are as follows:

Octagon: $S_5 = \frac{M_f}{.814d_p^2}$ (83)
Hexagon: $S_5 = \frac{M_f}{.832d_p^2}$ (83a)
Square: $S_5 = \frac{M_f}{.943d_p^2}$ (83b)
Circle: $S_5 = \frac{M_f}{.785d_p^2}$ (83c)

S_{all} = maximum allowable unit soil loading. (pounds/sq. ft.)
S_b = load on each foundation bolt. (pounds)
S_g = unit soil loading due to pull on guy wires. (pounds/sq. ft.)
S_{min} = total unit soil loading under minimum dead load conidtions. (pounds/sq. ft.)
S_t = unit stress in tower shell due to bending moment (M_t). (pounds/sq. ft.)
t = shell thickness. (feet)
u = bond stress (between concrete and reinforcing steel) per unit of area of surface of bar. (pounds)
V = velocity of wind. (miles per hour)
V_s = vertical shear load outside the critical section (see Figures 3 and 3c). (pounds)
W = total weight on soil (pounds) calculated by the following equation:

$$W = W_t + W_a \tag{3}$$

W_a = weight of auxiliary material and equipment supported by the foundation (pounds), including liquid in the tower, insulation, platforms, piping, etc. (Does not include weight of tower.)
W_h = weight of hammer. (pounds)
W_p = weight of foundation pedestal (top course). (pounds)
W_s = weight of empty tower. (pounds)
W_t = minimum dead load .(pounds) which is the weight of the empty tower plus the weight of the foundation, including the earth fill on top of the base.
Z = section modulus of the base of the foundation (to be based on foundation dimensions in feet) as follows:

$$Z = \frac{I}{c} \tag{11}$$

π = 3.1416
θ = angle which guy wire makes with the vertical. (degrees)
Σ_o = sum of perimeters of reinforcing bars within the limits of the beam width (ab). (inches).

US RUBBER AMAZON OIL TRANSPORT HOSE

UP-DATING AN AMAZING STORY:
Back in 1955 two lengths of U.S. Amazon Oil Transport Hose held a heavy tanker in check after she had slipped her moorings. The strain on the two hose was tremendous, but amazingly, Amazon held on. We told all about it in the advertisement shown here.
Today, three years later, a re-visit to this same dock revealed that one of these same lengths of Amazon is still in operation, doing a safe and efficient job.
We never recommend this kind of abuse for any hose—even Amazon. Still, it's nice to know that in buying U.S. Amazon you get a hose that has built-in reserve strength to command your complete confidence.

TANKER BREAKS LOOSE . . . "U. S." Hose holds on

Helplessly, the big tanker drifted away from the pier. She had slipped her moorings. Her sole connections with the shore were two lines of U. S. Amazon® Oil Transport Hose, one forward, one aft.

As the heavy, sluggish tanker edged further out, tremendous strain began to build up on the two hose, each consisting of two 25-foot lengths. *But U. S. Amazon Hose held.*

Soon each 50-foot line of hose was, as the picture above indicates, stretched like a rubber band—in fact, stretched out to 114 feet, over twice its normal length.

But U. S. Amazon Hose held—

When the tanker was brought back to the pier, astounded engineers removed the hose and tested it to 200 lbs. pressure. No leakage or other damage was found. Most amazing of all, each of these stretched and strained lengths recovered all but one foot of its original length.

This totally unexpected use of U. S. Amazon Hose as a hawser is a dramatic example of the value of "U. S." wire cord construction—which can take more longitudinal abuse or other deformations than conventional woven duck hose.

U. S. Amazon H-1515 is recommended for discharge—H-1818 for both suction and discharge service.

• • •

When you think of rubber, think of your "U.S." Distributor. He's your best on-the-spot source of technical aid, quick delivery and quality industrial rubber products.

US RUBBER **Mechanical Goods Division**

United States Rubber

Rockefeller Center, New York 20, N.Y. In Canada: Dominion Rubber Company, Ltd.

Valuable Reading Ahead

Here's a quick run-down on what's presented in this month's non-technical sections. These departments will keep you right up-to-date with what's new and different in this rapidly changing oil industry.

Energy Conversion Problem

Have trouble converting units of energy into their equivalents? All you need is a pencil and ruler plus the handy "energy conversion chart" in this month's "How To Do It."

Keep Going to Page 244

SBR for England

England is now producing her own synthetic rubber in a new plant at Fawley, England, while France has gone on stream with a new desulfurization plant at Martingues, France. These items and many more are in "Who's Building," the industry's most complete panorama of construction from all over the world.

Keep Going to Page 255

Air Pollution

The process industry has had many a headache over air pollution. But with modern industrial controls aiding the refineries, attention has turned to the role played by automobile exhausts. You can learn what two organizations are doing about the "auto problem" in "What's Happening in the Industry."

Keep Going to Page 311

Man Among Men

Union Oil's Clare Gard has just been presented the Hanlon Award Citation. You'll get the complete background of this man who has received the Industry's highest honor, when you read "What's Happening Among Men in the Industry."

Keep Going to Page 334

A Refining Hall of Fame

Among the special features in PETROLEUM REFINER's special Oil Centennial Issue coming up in January, 1959, will be a Refining "Hall of Fame" honoring those 15 or 20 individuals who have contributed the most to the Oil, Gas and Petrochemical processing industry. Like we said last month (PETROLEUM REFINER, April, page 164) we want each reader to submit the name of the one man he thinks has contributed the most to this industry. There are no special rules—if you think a man should be nominated, just let us know about it. All you have to do is write his name on the special postage-paid postcard just opposite page 392 of this issue. From these nominations, the final choice will be made for the Refining "Hall of Fame."

Keep Going to Page 393

BORDEN MANUFACTURES EVERY TYPE FLOOR GRATING

FOR THE REFINING INDUSTRY, in ferrous and non-ferrous metals

BORDEN—First in Floor Gratings — is proud of its particular adaption and specialization in gratings for the refinery industry. **Borden's** well-known attention to detail and great familiarity with this special field guarantees complete satisfaction.*

Trouble-free installation is assured by **Borden's** Free Planning and Checking Service: All details and dimensions are carefully checked with the customer before fabrication; the component parts are individually marked for economical, accurate and speedy erection in the field.

*This applies to grating (usually stainless steel) for vessel and tower internals — such as grid trays etc. — as well as for strictly structural applications.

See our Catalog in Sweets

Write for complete information on BORDEN All/Weld, Pressure Locked, and Riveted Floor Gratings in this FREE 16-page catalog

BORDEN METAL PRODUCTS CO.

823 Green Lane Elizabeth 2-6410 Elizabeth, N. J.
Southern Plant — Leeds, Ala. • Main Plant — Union, N. J.

BORDEN METAL PRODUCTS CO.

Gentlemen:

Please send me BORDEN Catalog

NAME .....
TITLE .....
COMPANY NAME .....
ST. AND NO. .....
CITY AND STATE .....

For more data on advertised products, use Readers' Service Cards, last page.

Reviewing New Books . . .

Corporate Diagrams

"Corporate Diagrams and Administrative Personnel of the Chemical Industry" includes 60 chemical, chemical processing, and petrochemical companies, 40 of which are shown by 11 by 17-inch organizational charts.

This reference is valuable to all who are active in the industries covered, by providing a better understanding and wider knowledge of the companies and their administrative personnel.

(Chemical Economic Services, 15 Chambers St., Princeton, N. J., 65 pages, $5.00.)

Refinery Engineering

This volume is both a text in petroleum refinery engineering, and a handbook of refinery engineering technology for practicing engineers and industrial technologists. The author covers the methods of processing petroleum, the design of refinery equipment, the evaluation of crude petroleum for the yield of products, the practical usefulness of petroleum products, and the cost of refinery equipment and its operation.

International interest is recognized in this fourth edition by the introduction of more information on foreign crude oils and more complete information on the evaluation of oils.

The chapter on Heat Transfer and Exchangers now includes the important interrelation between pressure drop and heat transfer. In a chapter entitled Evaluation of Oil Stocks, the highly important subject of forecasting the physical properties of the products from the characteristics of the parent crude oil are explained.

New material is presented in such fields as: solvent extraction, vaporization, fractionation, tubestill heaters, thermal cracking, coking, polymerization and alkylation, and platinum catalyst reforming.

(Petroleum Refinery Engineering, Fourth Ed., W. L. Nelson, McGraw-Hill Book Co., Inc., 330 West 42nd St., N. Y. 36, 960 pages, $15.00. For sale by Gulf Publishing Co., P. O. Box 2608, Houston 1, Texas, U.S.A.)

Analysis of Crude Oils

"Analysis of Crude Oils From 470 Important Oilfields in the U.S." contains routine analysis of 492 samples of crude petroleum from 470 U.S. oilfields, each of which produced 2,500 bpd or more during at least one of the years 1946-56. The fields are listed alphabetically by State and field names in table 1, with information on the geographical and geological sources of the samples. A table summarizes the general characteristics of the crude oils and analytical and computed data determined from the analyses.

Refractive index n_D and specific dispersion, n_g minus n_D divided by the density, for some of the distillate fractions are included in analyses of 316 of the crude oil samples. This is the first Bureau of Mines report on analysis of crude oils to contain such data, and their use in calculating hydrocarbon-type composition of the fractions is explained.

(Bureau of Mines, Report of Investigations 5376, Superintendent of Documents, U.S. Gov't. Printing Office, Washington, D.C., 276 pages, $1.25.)

Materials Handling

"Materials Handling Applications" by D. Oliphant Haynes, a companion volume to the author's "Materials Handling Equipment," is now available. It offers practical information on improving a materials handling program at commercial and manufacturing levels and is simple and non-technical in its approach.

The book emphasizes that the effective and economical adaptation of the materials handling job to the work area available is crucial to the solution of all types of materials handling problems. Haynes illustrates how such programs can be adapted to all kinds of situations in factories, railroads, trucks and loading platforms.

The various types of containers and the peculiar qualities of different materials are taken up individually. Haynes details handling techniques, discussing problems concerned with unusual and different sizes, shapes, weight, temperature, perishability, and bulk. Pointing out that manufacturing costs for transporting materials to spots along the production line are high, the book tells how to make a survey and interpret results realistically.

(Chilton Co., Book division, 56th and Chestnut Streets, Philadelphia 39, 381 pages, 1,100 illustrations, $12.50.)

Oral Communication

"Oral Communication of Technical Information" offers methods of effective speaking for almost all situations in a "how to" manner for technical men. Beginning with the bridges and barriers to effective communication, the book takes up the problems and how they are solved.

It covers organization of material, composition, delivery of formal and impromptu speeches, and the use of mechanical aids such as recordings and slides. How to preside at meetings, talk science to laymen, give technical legal testimony, and converse socially are covered in detail.

Emphasis is on the special needs of technical subject matter, but the techniques of organization and delivery apply to all speaking events. One section reviews common errors in speech-writing of chemists and engineers.

(Robert S. Casey, Reinhold Publishing Corp., 430 Park Ave., New York 22, 199 pages, $4.50. For sale by Gulf Publishing Co., P. O. Box 2608, Houston 1, Texas, U.S.A.)

Book of ASTM Standards

This is the 1957 supplement to Part 5 on fuels, petroleum, aromatic hydrocarbons, and engine antifreezes, in the 1955 Book of ASTM Standards. It contains the revised standards and the new and revised tentatives in these materials fields that have been accepted since the appearance of the 1956 Supplement to the 1955 Book of ASTM Standards. Seven of the eight standards are replacements of existing standards, and one standard represents the adoption of a tentative revision as standard.

(Book of ASTM Standards, 1957 Supplement, American Society for Testing Materials, 1916 Race St., Philadelphia 3, 345 pages.)

Aliphatic Flourine

"Aliphatic Flourine Compounds" covers the preparation and properties of all reported flourine compounds (except aromatic). Here is a concise collation of these compounds from Moissan's time to the present.

The book contains a discussion of 13 different methods of introducing flourine into an organic molecule. Detailed descriptions are given of all reported methods for the preparation of flourine compounds containing various functional groups. Also discussed is 286 methods of preparing these compounds, and materials.

(Aliphatic Flourine Compounds: Lovelace, Postelnek, and Rausch; Reinhold Publishing Co., 430 Park Ave., N.Y. 22, 370 pages, $12.50. For sale by Gulf Publishing Co., P.O. Box 2608, Houston 1, Texas, U.S.A.)

Future Supply of Oil, Gas

The primary contribution of this book is in establishing a "resource base" for the U.S. and adjacent continental shelf, which the author concludes contain about 500 billion barrels of oil and 1.2 quadrillion cubic feet of natural gas. These quantities will not necessarily be extracted or discovered, but are believed to be available for exploration.

In this report, technology is considered a dynamic factor of great importance in its impact on future oil and gas availability.

(The Future Supply of Oil and Gas, Bruce C. Netschert, Johns Hopkins Press, Baltimore, 134 pages, $3.00. For sale by Gulf Publishing Co., P.O. Box 2608, Houston 1, Texas, U.S.A.)

The Oilman's Barrel

This book consolidates, in interesting and understandable terms, the history and definitions of the now standard oil barrel, the units which make it up, and the legal pitfalls connected with it. It is a story full of the lore connected with the oil game—of odd-sized barrels in wagons for transporting the newly discovered petroleum in Pennyslvania in 1859, to the story of Nelly Bly, "mother of steel barrels".

(The Oilman's Barrel, Robert E. Hardwicke, University of Oklahoma Press, Norman, Okla., 122 pages, $3.75. For sale by Gulf Publishing Co., P.O. Box 2608, Houston 1, Texas, U.S.A.)

Heat Transfer Problems

"An Introduction to Heat Transfer" presents the fundamentals of heat transfer in a manner readily understood by third or fourth year engineering students. It provides a clear picture of the subjects' principles and their application to a variety of engineering problems. A good foundation may be obtained for advanced and more specialized studies in this field.

A chapter on fluid flow in the convection process provides background for those who have not studied fluid mathematics, and serves as a review for others. Another chapter on graphical and numerical methods for heat conduction problems provides methods of solution that are receiving increasing attention.

(Marco, Salvadore and Brown, McGraw-Hill Book Co., Inc., 250 Fifth Ave., New York 1, 332 pages, $6.75. For sale by Gulf Publishing Co., P. O. Box 2608, Houston 1, Texas, U.S.A.)

How Commercial Solvents Saves with Crane Valves

Here's a user experience with Crane valves that's worth noting.

In the Commercial Solvents plant at Sterlington, La., ammonia at 4500 psi. is let down to 300 psi. for process requirements. Despite frequent operation on this severe service, Crane No. 225H, 6000-pound forged steel valves have handled it safely since 1945.

More than that—with only routine maintenance—all these Crane plug-type disc globes are still giving leak-free, like-new service. Thirteen years of dependable, low-cost performance under toughest conditions!

That's typical Crane quality! Real, long-term value in valves and fittings for all fluid handling. The traditional choice of careful buyers who measure beyond the price tag.

THIS FREE BOOK—"Valve Performance Facts"—gives you 32 examples of savings with quality valves. Get a copy from your local Crane Representative, or write to address below.

CRANE VALVES & FITTINGS

PIPE • PLUMBING • KITCHENS • HEATING • AIR CONDITIONING

Since 1855—Crane Co., General Offices: Chicago 5, Ill. Branches and Wholesalers Serving All Areas

For more data on advertised products, use Readers' Service Cards, last page.

How To Do It

Here's a Handy Chart For Energy Conversion

Units of energy are easily converted to their equivalents by drawing a line perpendicular to the line of any known unit and extending it through the line containing the unknown units.

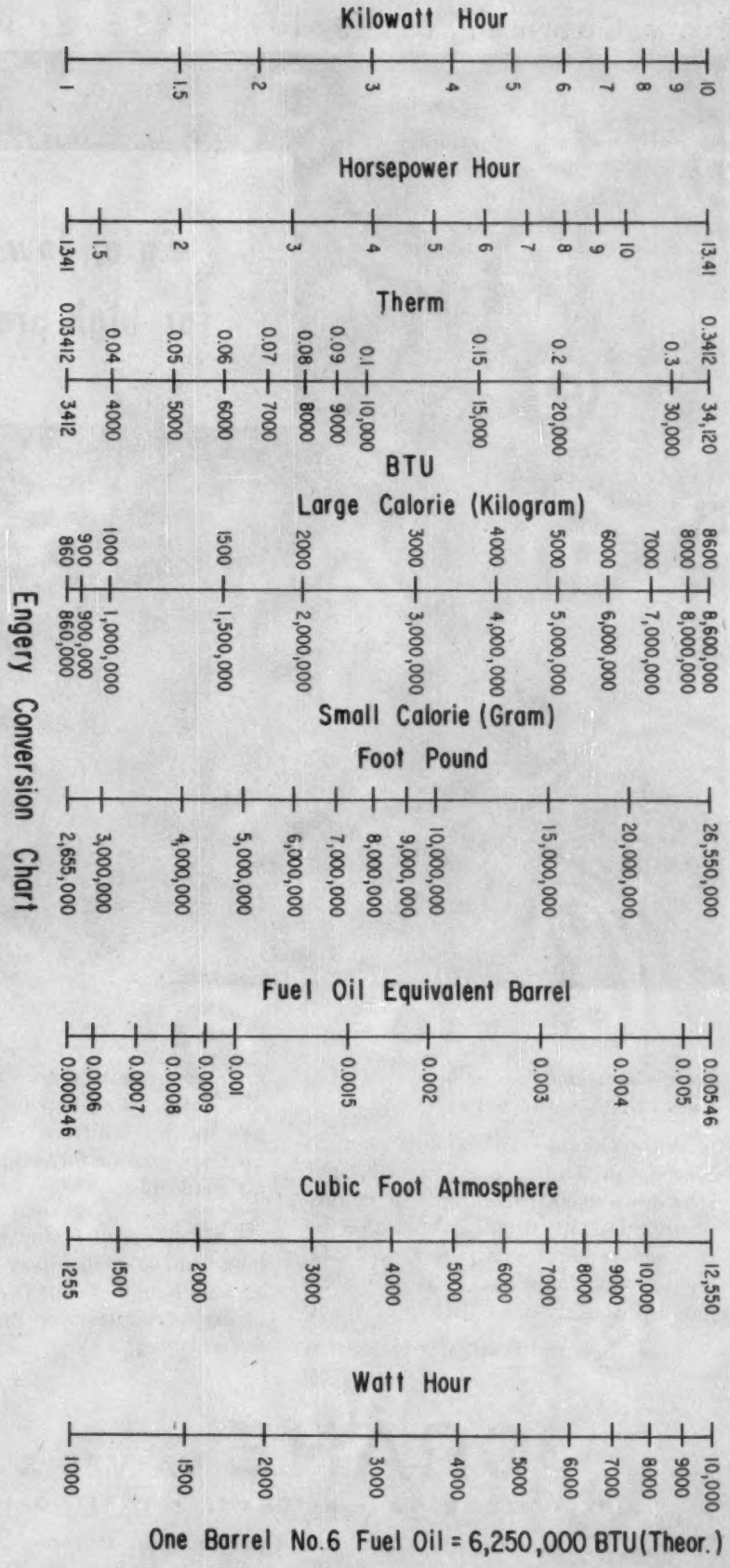
Note: In using the Fuel Oil Equivalent Barrel scale, the standard used was one barrel of No. 6 fuel oil equals 6,250,000 BTU (Theoretical).

Idea submitted by:
Marvin H. Green
Philadelphia

Use One Padlock to Secure Four Doors

One company mechanic fixed his tool box so that the snapping of one lock would effectively lock all sections of the tool box. The lock was made by running a tee-shaped bar through the handles of the front doors of the tool box and then slipping the eye, in the end, over a hasp and snapping the lock.

With the tool box in this shape, he can take off the lock and slip out the tee-shaped bar in a matter of moments, and all tools are quickly avail-



Monel Bubble Cups and Tray for top of new fractionating tower completely engineered and fabricated by Fritz W. Glitsch and Sons, Inc., Dallas, Texas. Notice Monel weirs and baffles.

Here's where Monel proves year-after-year resistance to common tower-top corrosives

Tower-top corrosion *can* be held within practical limits.

Monel* nickel-copper alloy bubble caps proved *that* long ago. Their record . . . at temperatures up to 500°F. . . shows outstanding resistance to the aqueous hydrochloric and sulphuric acids and the corrosive salts commonly present in this critical upper section.

Today, for towers handling corrosive streams, Monel alloy is preferred in this location.

The men with the sharp pencils say Monel alloy costs less per pound than other commercially available alloys able to withstand the corrosion in tower tops.

Fabricators such as Fritz W. Glitsch & Sons, Inc., find it is easy to form . . . lends itself well to lined or clad construction. Increasingly, they find it specified not only for caps and trays but also for distribution pipes, fittings, linings, the shell itself and overhead condensers.

Another advantage. Monel equipment can be field erected and easily repaired in the field. No heat treatment after welding is required to maintain corrosion resistance.

How is your tower down-time record? If it's not what it should be and corrosion is the cause, look into the possibilities of Monel alloy construction. Simply write Inco's Corrosion Engineering Section. *Registered trademark

The International Nickel Company, Inc.
67 Wall Street INCO New York 5, N.Y.

INCO NICKEL ALLOYS

CONDENSER TUBE CLINIC

Edited by **ARTHUR W. TRACY**, Metallurgical Engineer,
The American Brass Company, Waterbury, Connecticut

Stresses and their Effects can be Minimized

STRESS-CORROSION CRACKING—The stress-corrosion cracking of copper alloys requires the simultaneous action of moisture, air, ammonia, and stress. Stresses may be residual or applied. All Anaconda condenser tubes are processed so as to minimize residual tensile stresses which may be formed during fabrication. Applied stresses from installing tubes in heat exchangers, nonuniform thermal expansion in tube bundles, or misalignment of condensers with other equipment occasionally cause stress-corrosion cracking.

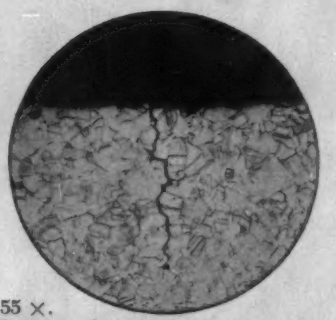
Admiralty metal and aluminum brass tubes, although known to be susceptible to stress-corrosion cracking, seldom crack in condensers. Although ammonia is often present, either by chance or design, in vapors entering condensers, the amount of air (oxygen) is usually so small that the corrosive action of the ammonia is limited. It is obvious that noncondensable gases should be vented from condensers, not only to increase thermal efficiency, but to minimize corrosion.

ANACONDA Arsenical Admiralty-439 and ANACONDA Ambraloy-927 condenser tubes seldom stress-corrosion crack in normal service. Where operating conditions are severe enough to cause stress-corrosion cracking of these alloys, ANACONDA Cupro Nickel, 10%-755 and ANACONDA Cupro Nickel, 30%-702 tubes are recommended.

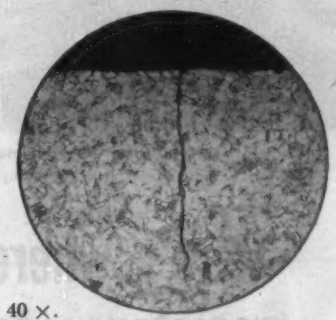
STRESS-RELIEF ANNEALING — Inasmuch as copper-alloy condenser tubes may stress-corrosion crack from stresses caused by cold-forming operations such as U-bending, the stresses should be removed by relief annealing the cold-formed portion of the tube.

FATIGUE CRACKING — Vibrations from moving parts of equipment or from pressure pulsations can induce stresses in condenser tubes high enough to exceed the endurance limit and cause a fatigue-crack failure. Vibration of a tube may even disturb water flow enough to cause impingement pitting at the point of greatest amplitude of vibration and the resulting pits can act as stress raisers. Pulsations can often be dampened by placing baffles or grids in the path of high-velocity vapors. Vibration of tubes can also be dampened by placing wooden slats between rows of tubes. Cupro Nickel, 30%-702 Tubes are more resistant to fatigue cracking than admiralty and aluminum brass.

TECHNICAL ASSISTANCE—Your tube problem may need special consideration. We are always ready to advise in the selection of the right alloy to give the best service. Write for the new edition of Publication B-2. The American Brass Company, Waterbury 20, Conn. In Canada: Anaconda American Brass Ltd., New Toronto, Ont. 5678



55 ×.
Intergranular stress-corrosion crack in 70/30 brass tube from oil refinery heat exchanger. Longitudinal section.



40 ×.
Transgranular stress-corrosion crack in admiralty metal tube from oil refinery heat exchanger. Longitudinal section.

40 ×.
Fatigue crack starting at pit in aluminum brass tube from power plant condenser. Longitudinal section.

ANACONDA® Tubes and Plates for Condensers and Heat Exchangers

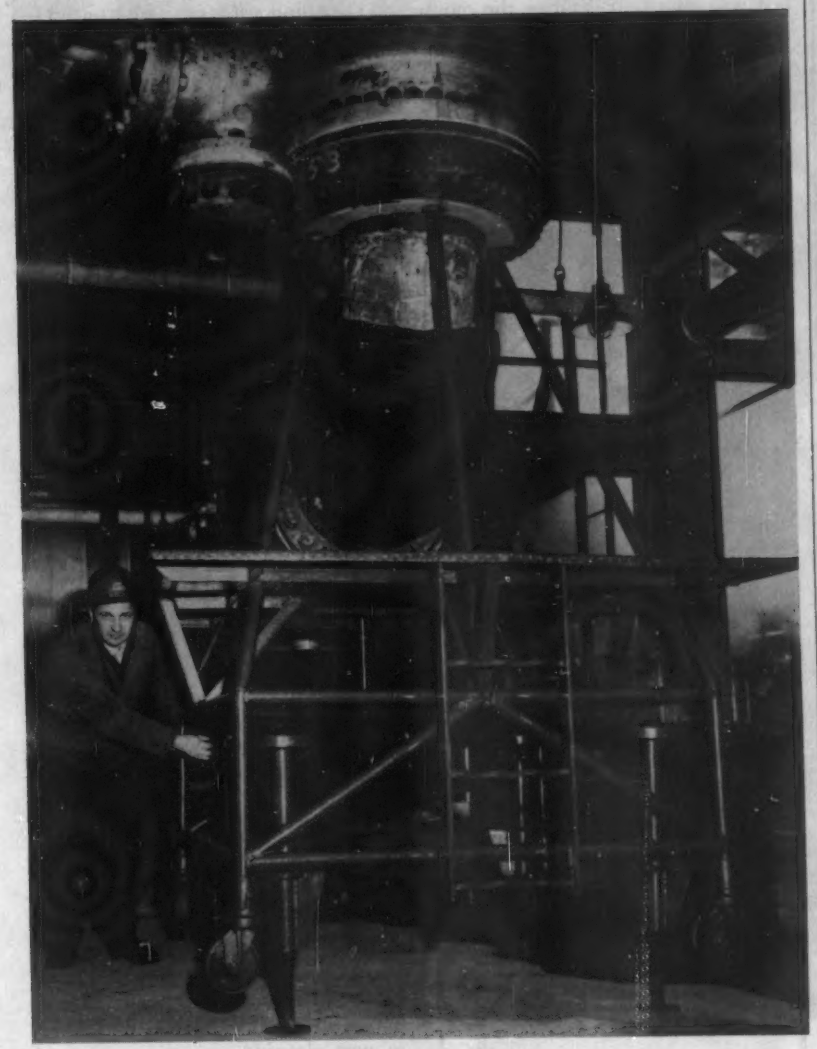
NOMINAL COMPOSITIONS OF SOME ANACONDA CONDENSER TUBE ALLOYS

	Arsenical Admiralty-439	Ambraloy-927 (Aluminum Brass)	Cupro Nickel, 10%-755	Cupro Nickel, 30%-702
Copper, %	71	77	88.35	68.90
Nickel, %	..	..	10	30
Zinc, %	27.96	20.96	..	..
Aluminum, %	..	2	..	..
Tin, %	1	..	..	..
Arsenic, %	0.04	0.04	..	..
Manganese, %	..	..	0.40	0.60
Iron, %	..	..	1.25	0.50

For more data on advertised products, use Readers' Service Cards, last page.

able. Yet, they are stored safely when the tool box is locked.

Idea submitted by:
Harry Hess
Havana, Cuba



Jacks and Dolly Handle Five-Ton Elbows

Handling the massive steel "els" of the new catalytic reformer in The Atlantic Refining Company's Philadelphia refinery was quite a problem until Mechanical Foreman Joseph Karol designed a special rig to do the job. There is an "el" at the base of each platinum catalyst reactor which must be taken down to remove the catalyst. Since each one weighs nearly five tons, handling the piece was no easy matter.

The rig, shown in the picture with its designer, is a combination scaffold, jack and dolly. It can be raised on the jacks to support the heavy "el." In this position, workmen can stand on its platform to loosen the many bolts. Once lowered and resting on the wheels, it can be moved out of the way to be worked on or to allow the catalyst to be emptied.

Item courtesy of
The Atlantic Magazine

Make Motor Coil Rewinding Machine Out of Old Lathe

A motor-driven, coil winding machine was made from a discarded

ROCKWELL
WAFER
BUTTERFLY
VALVES

For dependable flow control and wedge-tight shut-off of air, gases, steam and any liquids or semi-solids at pressure differential to 150 psi—

For use in power generating, cooling, refrigerating, dust collecting, compressing, processing, refining, gas transmission, combustion control, waste disposal and water works—

For easy, space-saving installation at lower cost.

They're built for
HEAVY DUTY

- Slim-trim—compact.
- Smallest face-to-face dimension; require but one set of flange bolts.
- Lightweight but rugged.
- Made of any metal or rubber-lined.
- Use any manual or automatic operators.
- Standard sizes—4" to 36"; special smaller and larger sizes.

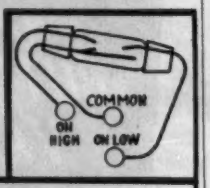
Bulletin 580 tells how they meet your needs.

W. S. ROCKWELL COMPANY
2368 ELIOT STREET
FAIRFIELD, CONN.

For more data on advertised products, use Readers' Service Cards, last page.

Three Operations One Control

MULTI-PURPOSE PRESSURE CONTROL



Single pole, cut in high (close on rise)

Single pole, cut in low (open on rise)

or Single pole, Double throw

PROVIDES

- **External Adjustments**
- **Repetitive Trip Point**
- **Repetitive Reset Value**
- **Visible Calibrated Dial**
- **Visible Contact**

Note Minimum Differentials for each Range

Adjustable Operating Range Psig	Maximum Momentary Surge	Min. Diff. Psig
0-30" Vac.*	30	2"
10" Vac. 12#*	30	1#
0-14#	30	1
0-20#	30	1
0-35	50	1¼
0-60	125	3
0-60	150	6
0-100	125	3¼
0-100	200	6
0-100	300	6
0-150	200	7
0-150	240	8
0-150	300	8
0-200	240	8
0-200	300	8
0-300	400	12
0-300	600	14
0-600	800	50
0-1000	1500	75

Series DA 20, 30, 50, 60, listed by UL and CSA

THREE CASE STYLES AVAILABLE

GENERAL PURPOSE (NEMA 1) Illustrated —for indoor use.

WEATHER-PROOF (NEMA 1A, 2, 3, 4,)— for outdoor use.

EXPLOSION-PROOF (NEMA 7)—for hazardous locations.

WRITE FOR CATALOG NO. 858

THE MERCOID CORPORATION

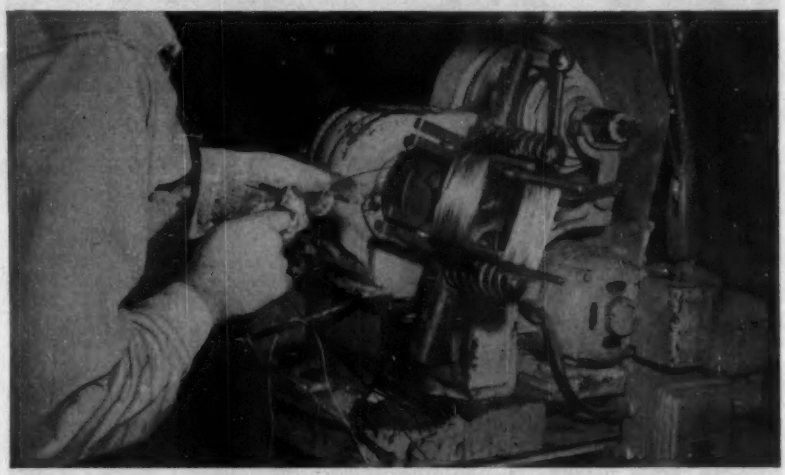
CHICAGO 41, ILL.

How to Do It . . .

lathe at The Dow Chemical Company's Freeport plant. The old lathe bed was sawed-off, leaving the motor and gearing; the adjustable coil winder was placed in the chuck. The reduced speed makes the winding operation slow enough to perform a good job on rewinding small motors.

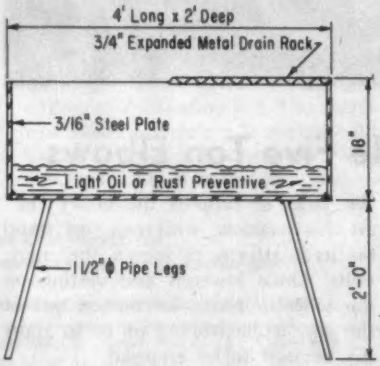
An ordinary fluorescent desk lamp, attached to the back of the lathe, provides the electrician with extra light to guide the wire in the rewinding procedure.

Item and photograph courtesy *The Dow Texan*, a publication of the Texas Division of The Dow Chemical Company, Freeport, Texas.



Dipping Vat For Parts Cuts Cleaning Man-Hours

Have you ever ordered a machined part from your stores to find the surfaces rusted or covered with a heavy plastic coating? Either requires considerable time to clean for usable service.



Here is an item made from steel plate, pipe and expanded metal that will save warehousing and craft time in preserving parts subject to rusting.

A vat can be made similar to that shown in the drawing. Approximately 15 gallons of light oil or prepared rust preventive is then placed in the vat. When a part is received, it is dipped in the oil and placed on the drain rack. An inexpensive wrapping paper completes the job of storing the part in stock.

This procedure eliminates the slow and expensive method of plastic coating or wrapping in moisture-proof paper, and will cut craft man-hours in part cleaning.

Idea submitted by:
B. W. Cooper, Ethyl Corporation
Pasadena, Texas

Vise Stand Gets Mechanic Away From Crowded Bench

A vise stand can be made for your shop by using an old pipe flange for the base plate to which is welded a 36-inch piece of four-inch pipe. The vise table is made from ½-inch steel plate to which is welded a lip formed with one-quarter steel plate and welded to the table.

The stand provides a convenient method for using a vise away from

THIS MAN CAN ADD TO YOUR PROFIT PICTURE. This is a Dowell service engineer—on the job. His knowledge and abilities in chemical cleaning can help you to greater profits. Recently, an eastern corporation used Dowell Service for its boiler cleaning maintenance. Dowell's service engineer studied the problem, did the job. His use of chemical solvents in cleaning tubes and other metal surfaces was effective. On the basis of Dowell Service, this company will realize improved profits of $440,000.

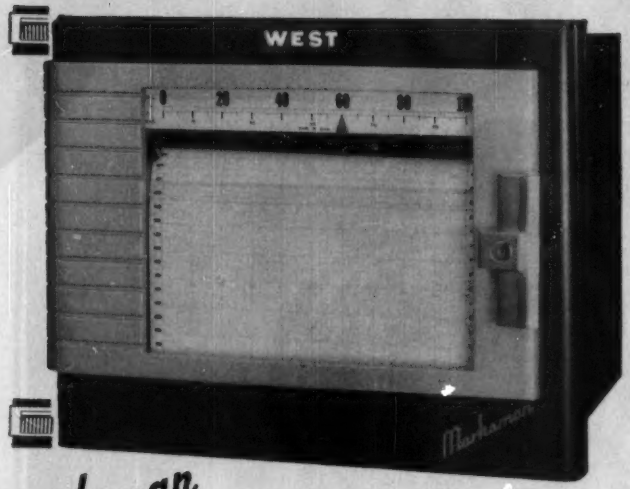
There are three ways you can clean your plant equipment: *Mechanically* with your own crews—inefficient, time consuming and expensive in today's industrial pace. *Chemically* with your own crews—again inefficient and unprofitable because of heavy payroll and the personnel's lack of qualification. Or with *Dowell Service,* the modern chemical cleaning method.

With Dowell Service you receive the benefits of more than fifteen years experience in chemical cleaning—plus special equipment, chemicals, research and trained personnel. You pay one charge, get an efficient job, handled by knowledgeable people.

Every industry can profit from Dowell Service. Ask your maintenance and operating engineers if they have thoroughly investigated the profit possibilities of using Dowell Service. DOWELL INCORPORATED—A SERVICE SUBSIDIARY OF THE DOW CHEMICAL COMPANY. Headquarters and research center, Tulsa, Oklahoma; 165 offices and stations to serve you.

Chemical cleaning service for industry DOWELL

how many?



Marksman RECORDERS by WEST

Now in full production, these completely new tubeless potentiometer strip chart recorders are ready to go to work for you.

Get these features in all standard models at no extra cost:

- Transistorized Amplifier
- Printed Circuits
- Dial 5 Chart Speeds
- Chart Tearoff Strip
- Automatic Standardization
- Standardizing Indicating Light
- Built-in Chart Saver
- Plug-in Construction
- Separate Chart Re-Roll Motor
- Infinite Resolution Slide Wire
- Eleven Inch Calibrated Chart Width
- Will Mount in 19 Inch Relay Rack

Yours are ready! For data or demonstration, write for Bulletin M or phone your West representative listed in the Yellow Pages.

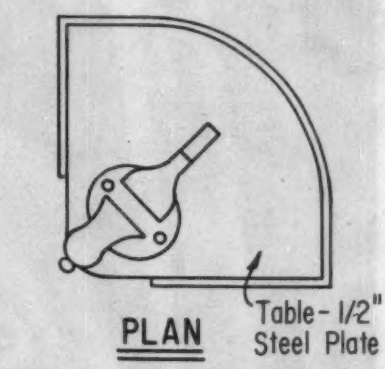
WEST *Instrument* **CORPORATION**
SALES OFFICES IN PRINCIPAL CITIES
FACTORY AND GENERAL OFFICES:
578 W. MONTROSE, CHICAGO 41, ILL.
BRITISH SUBSIDIARY:
WEST INSTRUMENT, LTD.
52 Regent St., Brighton 1, Sussex
Represented in Canada By: Upton, Bradeen & Jones

the trend is to **WEST**

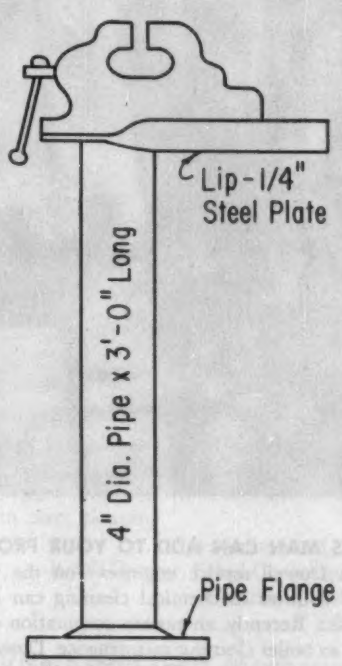
How to Do It . . .

a cluttered workbench and also gives the mechanic a place to lay his tools and parts while he is using the vise.

Idea submitted by:
Jack O. Evans
E. I. du Pont de Nemours & Co.
Victoria, Texas



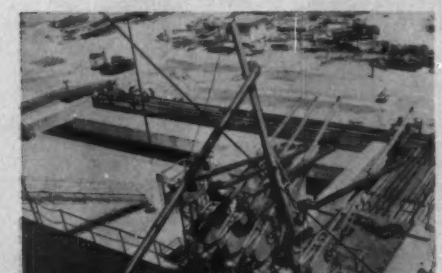
PLAN



ELEVATION

At least $10 will be paid for each idea accepted for "How to Do It." Just send a brief note with a photo or sketch to the Editor, *Petroleum Refiner*, P. O. Box 2608, Houston.

RICHFIELD INSTALLS NUMBER FOUR



Where once seven men labored 30 minutes to hook up rubber hose, now one man operating hydraulic controls swings a Chiksan Loading Arm aboard, ready for hook up, in less than a minute. There are 96 Chiksan Marine Loading Arms in service throughout the world. Many more are on order.

Richfield, like other users who are reordering, has installed still another bank of Chiksan Marine Loading Arms.

The first bank of Chiksan Marine Loading Arms on the West Coast went into service at Richfield's Terminal No. 2 in May, 1956. Subsequently, two additional banks of five were installed to render the facility among the most modern anywhere. This terminal has since handled over 50 million barrels of crude and refined products of many grades. Now, with growing need for greater transfer capacity, Richfield has ordered and installed an additional bank of three arms.

On every count, Safety, Economy, Speed, the Chiksan Marine Loading Arm measures up. So substantial are the savings gained from faster loading, greatly reduced replacement costs, fewer loss-time injuries, and elimination of rupture potential, that in many cases these savings can easily amount to the actual purchase price within three years.

Send for informative bulletin and payout analysis today.

fmc

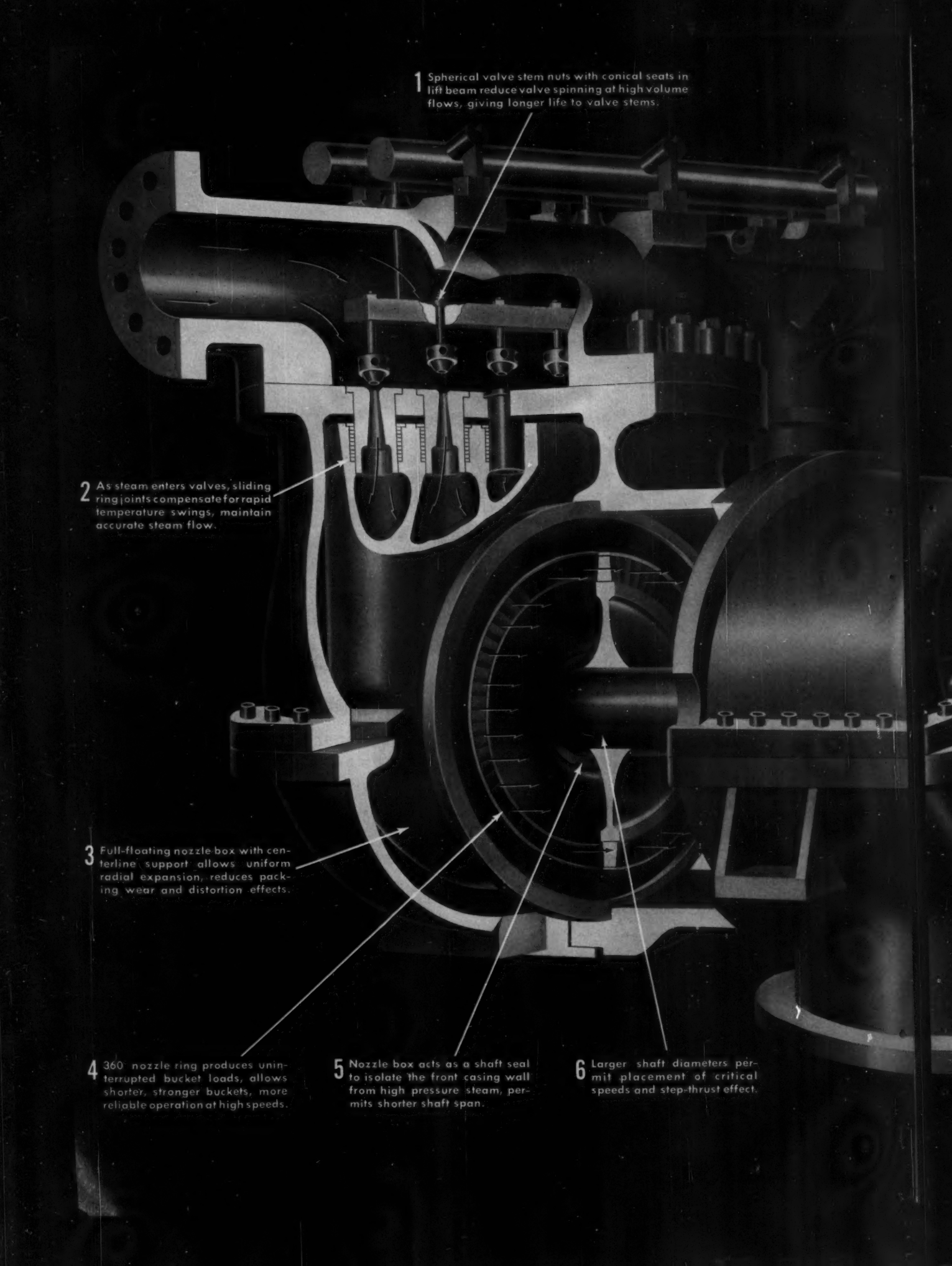
A SUBSIDIARY OF FOOD MACHINERY AND CHEMICAL CORPORATION

CHIKSAN

CHIKSAN COMPANY—BREA, CALIFORNIA • CHICAGO 5, ILLINOIS • NEWARK 2, NEW JERSEY

Well Equipment Mfg. Corp. (Division), Houston 1, Texas • Subsidiaries: Chiksan Export Company • Chiksan of Canada, Ltd.

#58-33


1 Spherical valve stem nuts with conical seats in lift beam reduce valve spinning at high volume flows, giving longer life to valve stems.
2 As steam enters valves, sliding ring joints compensate for rapid temperature swings, maintain accurate steam flow.
3 Full-floating nozzle box with centerline support allows uniform radial expansion, reduces packing wear and distortion effects.
4 360 nozzle ring produces uninterrupted bucket loads, allows shorter, stronger buckets, more reliable operation at high speeds.
5 Nozzle box acts as a shaft seal to isolate the front casing wall from high pressure steam, permits shorter shaft span.
6 Larger shaft diameters permit placement of critical speeds and step-thrust effect.

New full-circle nozzle ring helps give more

PROFITABLE POWER

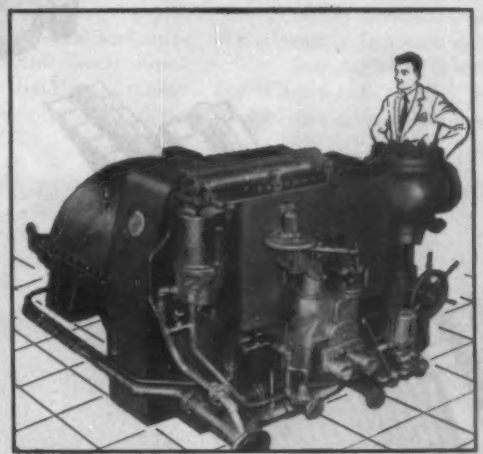
at high ratings, high speeds with General Electric turbines

The new 360° nozzle ring available on General Electric high-volume flow turbines allows horsepower ratings to 15,000 and speeds to 12,500 rpm without appreciable increase in turbine dimensions. Now you can drive high-speed compressors more efficiently with powerful General Electric mechanical drive turbines.

Greater reliability is realized in these G-E high-speed turbines because the unique 360° nozzle ring distributes power to all of the buckets. This reduces bucket loading and increases turbine reliability.

Turbine maintenance is greatly simplified because there are few high-pressure joints and no jumper pipes in this one-piece internal shell.

Ask your nearby G-E Apparatus Sales Office for details on how mechanical drive turbines can help bring profitable power to your high-speed applications—or write to General Electric Company, Section 241-11, Schenectady 5, N.Y.



THIS G-E TYPE DRV MULTIVALVE mechanical drive turbine meets stiff process requirements under conditions of frequent load fluctuations or where there is large volume steam flow.

Progress Is Our Most Important Product

GENERAL ELECTRIC

BLUE-dyed Asbestos tells you that your Flexitallic Gasket is

RIGHT FOR A GIVEN SERVICE

Practices in design and construction make Flexitallic Gaskets different from others in the spiral-wound industry. In Flexitallic Gaskets, the compression characteristics for a given pressure series are *always* related to the bolting load for that series.

Once the design is right for a given service, Flexitallic Gaskets are made under exacting mechanical controls to assure that manufactured gaskets conform to specification.

The blue dye in the Canadian asbestos filler indentifies Flexitallic Gaskets for engineers who want the right gasket for each sealing requirement.

Whatever the service conditions may be—vibration, weaving, thermal and mechanical shock, and other joint stresses—the precision design and construction in Flexitallic Gaskets are your assurance of satisfactory service.

FLEXITALLIC GASKET CO.
8th & Bailey Sts. Camden 2, N.J.
Representatives in principal cities

Flexitallic®
SPIRAL-WOUND GASKETS

FOR PIPE FLANGES, PRESSURE VESSELS AND PROCESS EQUIPMENT

*Flexitallic is a registered tradename. No one else can make a Flexitallic Gasket. Look for *Flexitallic Blue* — it's our exclusive blue-dyed Canadian asbestos filler.

Who's Building . . .

England Now Makes Synthetic Rubber

New plant at Farley to make 50,000 tons of synthetic rubber annually.

The International Synthetic Rubber Company, Ltd., will produce 50,000 long tons of SBR synthetic rubber a year in a new plant going into service this month. Located near Fawley, England, it is that country's first entry into synthetic rubber production. Design and construction of the new facility was done by Chemical Plants Division, Blaw-Knox Company, Pittsburgh, Pa.

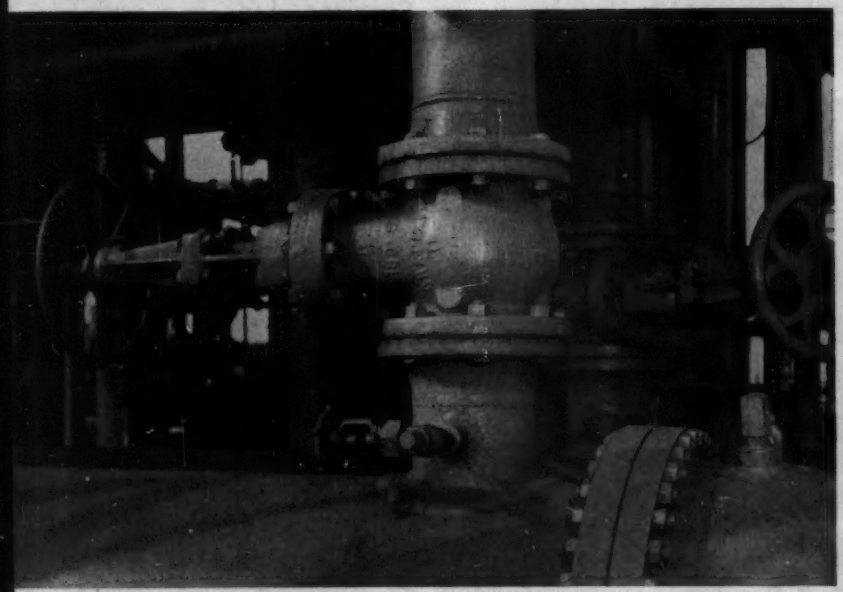
Preliminary engineering work needed to develop material and utility balances, process flow sheets, functional equipment, building layouts and certain specifications was done in the firm's Pittsburgh office. After shipment of the design drawings to England, definitive construction drawings including all architectural, structural, piping, heating, and electrical work were prepared and equipment purchased in England.

Blaw-Knox has also been retained to supervise the initial start-up, train the operating personnel, and prepare the necessary instruction manuals.

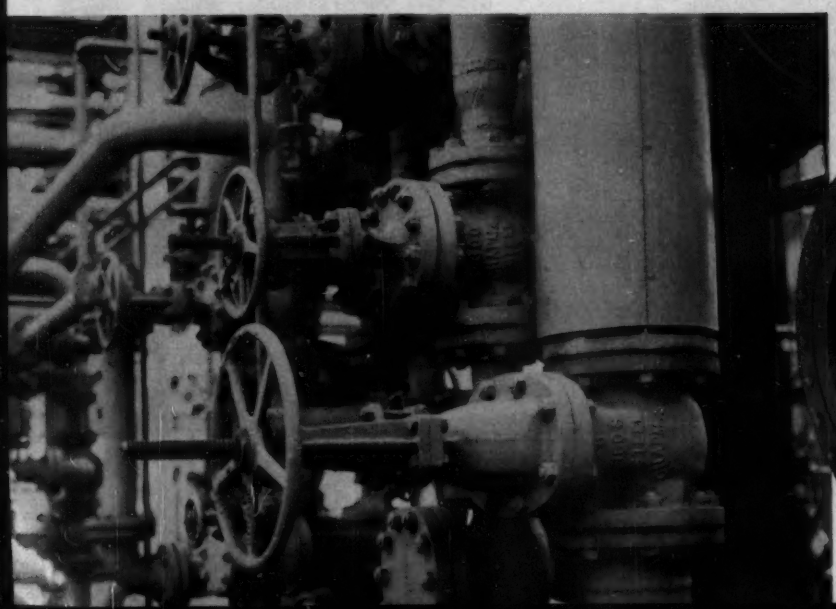
The International Synthetic Rubber Company, Ltd., is a newly formed company organized by Dun-

First plant for the newly formed International Synthetic Rubber Company, Ltd.

New England Refinery

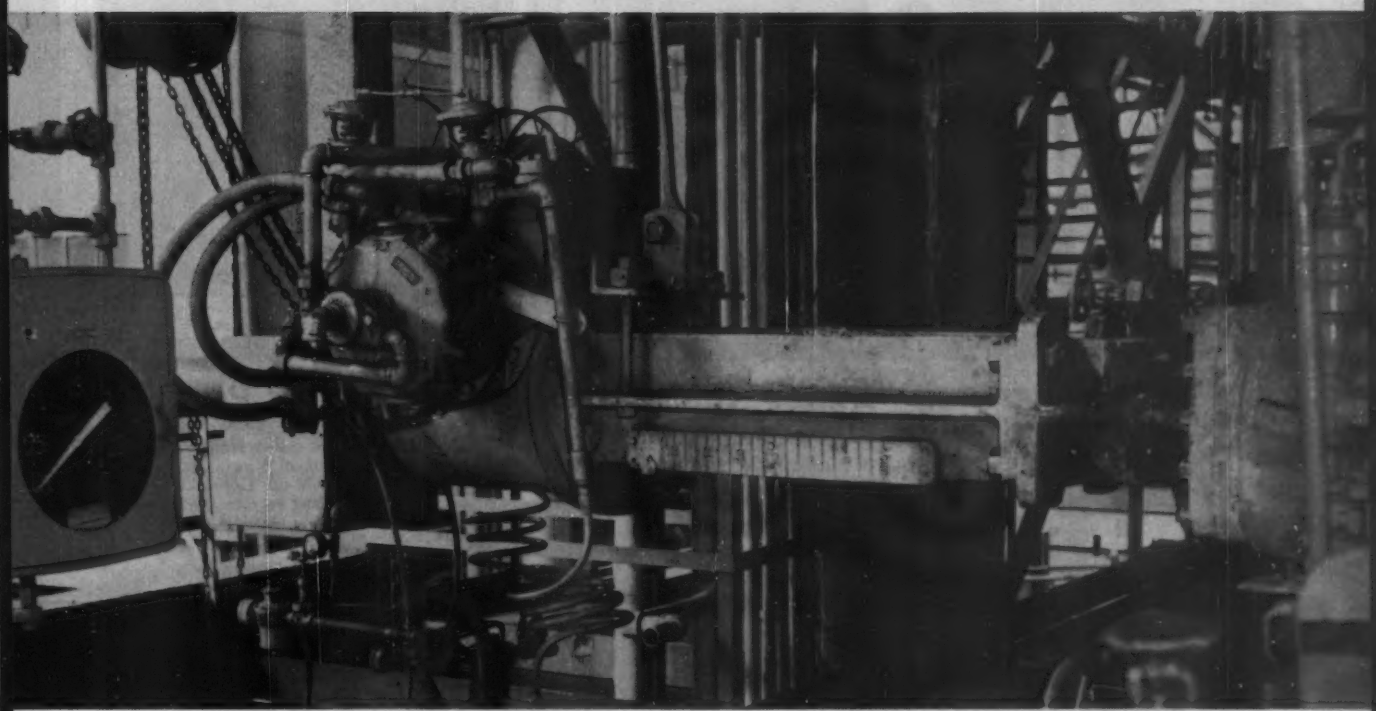


Above and below, some of many Chapman Valves giving service at New England Refinery at Everett.



U-bend valve with Coniflow Control designed and built by Chapman for catalytic cracking service.

uses CHAPMAN VALVES



U-bend valve installed in horizontal position at New England Refinery.

This isn't just a regional story. Far from it. In addition to the New England Refinery in Everett, Massachusetts, the Esso Standard Oil Company has other refineries at Linden, New Jersey; Bayonne, New Jersey; Baltimore, Maryland; Baton Rouge, Louisiana and Charleston, South Carolina.

These, like other leading refineries in all parts of the world, use Chapman Valves . . . both standard and special . . . *for good reasons.*

Chapman has all the engineering and manufacturing facilities to think out and work out valves that will fully meet the requirements of today and, just as important, to meet tomorrow's requirements.

Esso's New England Refinery is a good example of meeting these requirements. When World War II brought on an urgent demand for better and cheaper gasoline and fuel, a new method . . . catalytic cracking . . . was developed. Today, with this added miraculous giant known as a "cat cracker," built by Foster Wheeler, the New England Refinery is a still more modern plant. Tanks with a total capacity of 60,000,000 gallons can be filled with finished products. Some of this production is delivered to all of New England and to parts of New York State to meet industrial, automotive and domestic needs . . . a real, important service.

The CHAPMAN *Valve Manufacturing Co.*

INDIAN ORCHARD, MASSACHUSETTS

It pays to talk about your valve requirements for today and tomorrow with Chapman. The Chapman Valve Manufacturing Company has the men, the brains and the facilities to meet these requirements fully, no matter how tough they are. Chapman has the engineers, metallurgists, experience, and manufacturing capacity to produce the valves you need. Write, and we'll gladly consult with you.

Who's Building...

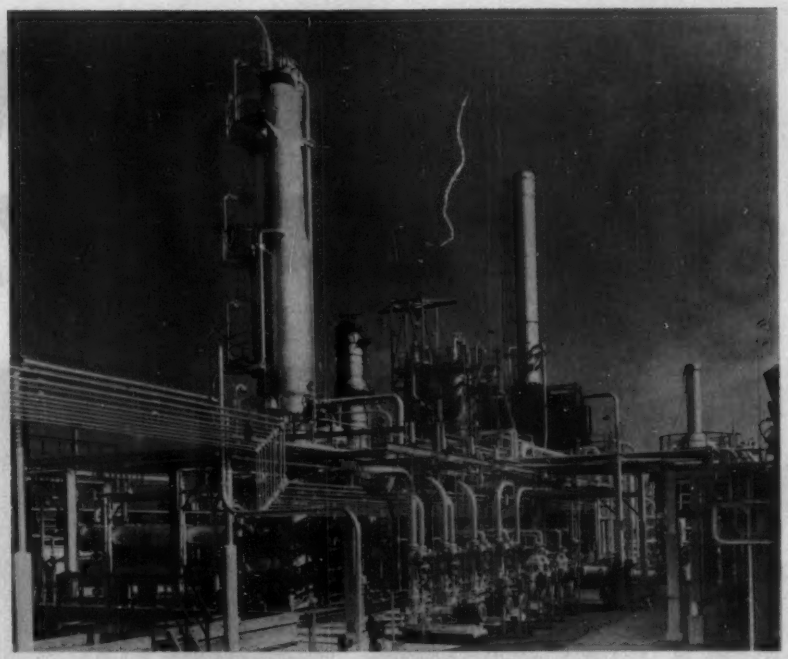
lop Rubber Company, Ltd., The Goodyear Tire & Rubber Co. (Great Britain) Ltd., The Firestone Tire & Rubber Co., and Michelin Tire Co., Ltd.

Koa Oil Co., Ltd.'s Marifu, Japan, refinery has started an unusual operation in which the aromatic-rich product from a UOP Platforming unit is supplied directly to the adjacent plant of the Mitsui Petrochemical Industries, Ltd., as part of the feed stock for a Udex unit.

The Koa Platformer has a design capacity of 1,800 bpsd. It is processing naphtha, derived from Middle East crudes, which boil in the range of 150 to 300° F. Another Platformer, which went on stream in December 1953, at the Koa refinery is operating exclusively to produce high octane motor fuel blending component.

The other portion of the feed stock for the Udex installation is an aromatic coproduct from the cracking of naphtha to produce ethylene, which has been hydrogenated and purified in a new 500-bpsd Unifining unit recently put into operation at the Mitsui plant. The Udex unit is producing high purity benzene, toluene and xylenes which are raw materials for some of Mitsui's petrochemical production.

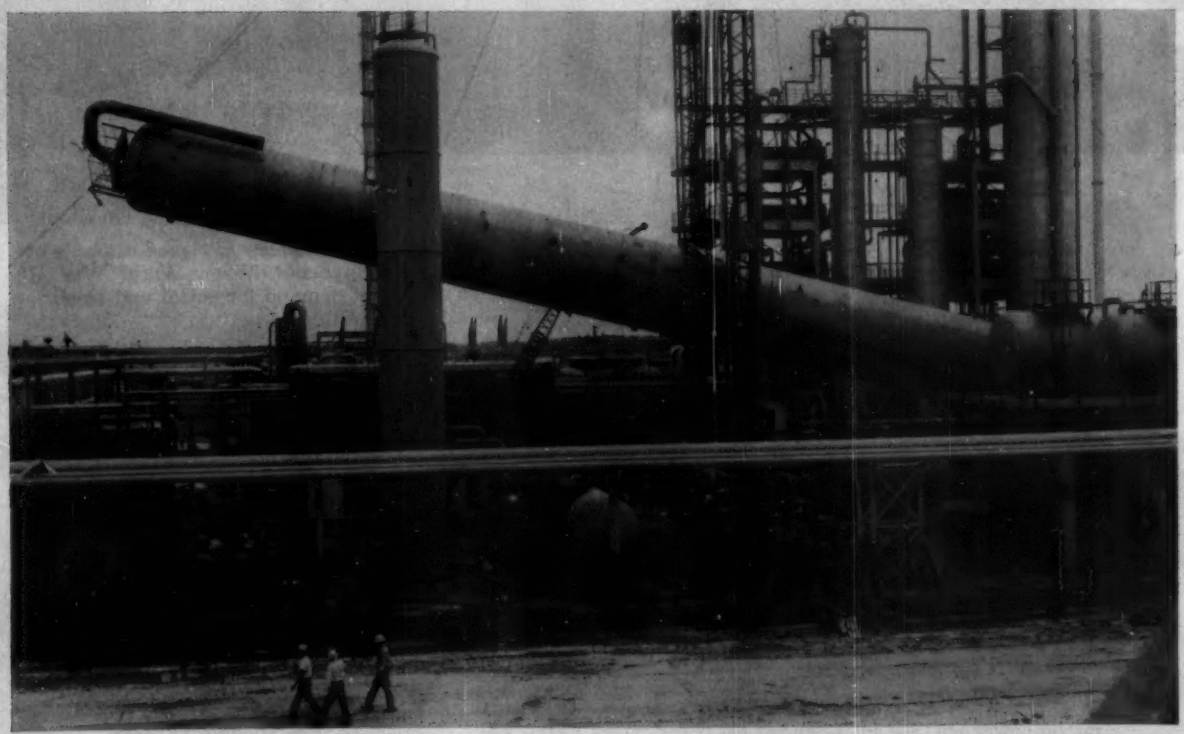
Callery Chemical Co. is building hydrogen, nitrogen, and carbon dioxide production and purification units for its $38-million high-energy fuel plant at Muskogee, Okla. Girdler Construction division, National Cylinder Gas Corp., has the $3.4-million contract.



This unit designed to remove 85 percent sulfur from oil gas.

Sulfur Removal Now Gives Better Products

The new Desulfurization Unit at Compagnie Francaise de Raffinage's Provence refinery, Martigues, France, has gone on stream. The unit was designed to remove 85 percent of the sulfur from 12,500 bpd of a 80/20 blend of virgin gas oil and light catalytic cycle oil. Cobalt Molybdate catalyst is employed for the reaction. The



Tellepsen Petro-Chem erects 215-ton fractionating tower in one piece at Cities Service's Lake Charles refinery.

NOOTER

FLOATING ROOF TANKS

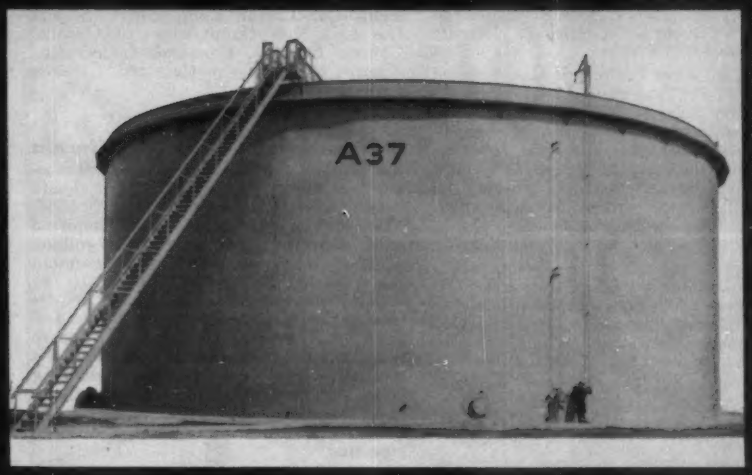
Offer You

MAXIMUM

SEAL PROTECTION

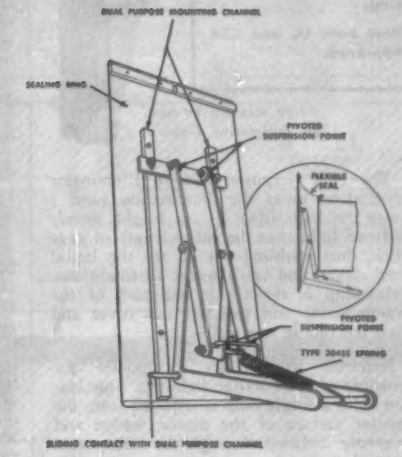
MINIMUM

MAINTENANCE

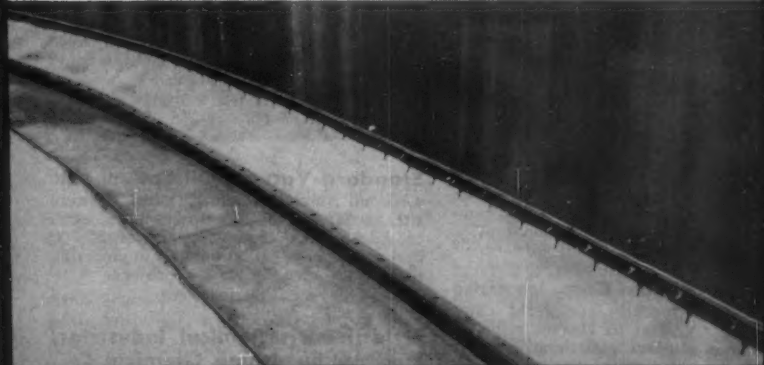


NOOTER is fully experienced in the fabrication and erection of double deck, pontoon and pan type floating roofs—all with the patented Nooter Seal. The Nooter design means better protection for your product because of the more efficient seal . . . minimum maintenance because there is no direct contact with the sealing ring, therefore minimum wear . . . and minimum delay in construction because easier installation and alignment are made possible by the new seal design. These advantages mean a better floating roof tank at a lower cost.

This Patented NOOTER SEAL HANGER is One Reason Why!



This exclusive Nooter 2-Point suspension seal hanger has one pivoted and one sliding point of contact with the dual-purpose mounting channel. This channel serves (1) as a means of attaching seal hanger to shoe without direct contact of seal hanger to shoe, and (2) as a method of providing even distribution of the forces of seal hanger over entire height of shoe.



you can also update your old tanks with the new NOOTER SEAL

The Nooter Seal is readily adaptable to any existing welded or riveted tank. Requires minimum modifications for fast, easy installation.

For your next floating roof tank, or seal replacement, send your inquiries to Nooter. You'll find Nooter quality and dependable deliveries your best equipment investment.

Catalog 158 on Nooter Floating Roof Tanks is yours for the asking.

NOOTER CORPORATION

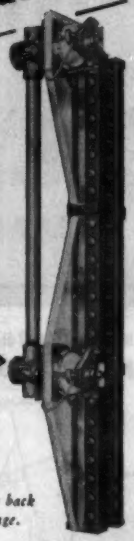
"Since 1896"

Steel and Alloy Plate Fabricators and Erectors..."Boilermakers"

1404 SO. SECOND ST. • ST. LOUIS 4, MO.

New Improved JERGUSON Gage Illuminator

gives up to 3 times the illumination



Low cost explosion-proof lighting of entire gage glass with no glare or blind spots

New Features:

Simplified Relamping . . . loosen one thumb screw to lift out cover and glass housing in one piece.

New Safety Chain prevents accidental dropping.

Now both UL and CSA Approved.

Easily mounted on back of Transparent Gage.

The New Jerguson EPL-56 Illuminator gives three times the illumination (and 3 times the bulb life) . . . a bright, evenly diffused light over the entire length of gage glass, thus enabling you to see the liquid level clearly and easily under all conditions. Relamping is simplified: one turn of the thumb screw and you lift out cover and glass housing in one piece.

Jerguson Illuminators incorporate the principle of solid wedge lighting. Illumination from a single bulb is reflected from the angular surface of the plastic wedge and is evenly diffused through the transparent gage glass.

Jerguson Illuminators are UL approved and are built in accordance with their Standard for Electric Lighting Fixtures for use in hazardous locations for Class 1, Group D Services. They are made in a variety of sizes.

Write for Data Unit on Process Gage Illuminators.

JERGUSON

Gages and Valves for the Observation of Liquids and Levels

JERGUSON GAGE & VALVE COMPANY

100 Adams Street, Burlington, Mass.

Offices in Major Cities

Jerguson Tress Gage & Valve Co., Ltd., London, Eng. Pétrole Service, Paris, France

Who's Building . . .

various conditions of the catalytic processing have been based on research conducted by CFR and The M. W. Kellogg Co. in their laboratories and pilot plants. This unit is also designed to accommodate straight-run naphtha and kerosene as alternate feed stocks. Desulfurization to about 75 percent is expected for alternate operations.

Although most equipment was designed for the 12,500 bpd gas oil operation, certain items have an increased capacity to permit a throughput of 10,000 bpd of straight-run naphtha. For the kerosene operation, the throughput is 7,000 bpd which represents a balance between the degree of severity required for desulfurization and adequate product color.

A two-reactor system is provided to furnish operational flexibility. Design space velocity for the gas oil operation can be maintained while operating the plant at 50 percent of full capacity. A summary of operations follows:

	Gas Oil	Kerosene	Naphtha
Fresh Feed bpd	12,500	7,000	10,000
Desulfurized Product bpd	11,900	6,976	10,007

This unit employs a unique method of reactor effluent separation which is more advantageous than the customary scheme of cooling, flashing and stripping. A progressive flash and recycle gasoline absorption method permits a much higher percentage of hydrogen in the reactor recycle gas stream than would otherwise be possible. Secondly, a saving in heat and heat exchanger surface results from sending combined liquids to the product stripper. Thus these liquids do not have to be reheated and heat not expended is used to heat the feed oil.

In addition to the feed preparation, M. W. Kellogg has designed and constructed a catalytic section, a product recovery system and a catalyst regeneration system.

Standard Oil Co. (Ohio) is on stream with a new $3.4-million alkylation unit at its Cleveland Number 1 Refinery. This new unit, built by Arthur G. McKee & Co. of Cleveland, will have a daily capacity of 150,000 gallons of high octane gasoline components. It is an advanced version of the alkylation plant constructed at the company's Toledo refinery in 1953, which is used to produce components for aviation gasoline.

The feed stock for the new Cleveland unit is butane gases from the catalytic cracking operation. A sulphuric acid catalyst is used in the new alkylation unit.

The Bay Petroleum Corp. has started operation of a recently completed catalytic reformer unit at its Denver refinery. The new unit employs a platinum catalyst to convert low-octane naphthas into blending components for high-octane gasoline. The addition has a capacity of 3,800 bpd, and was designed and constructed by The M. W. Kellogg Co.

Societa Mediterranea Raffineria Siciliana Petroli plans to build a refinery near Milazzo, Sicily. It will have a capacity of 50,000 bpd with a possible expansion to 100,000 bpd.

Northwest Oil Sands Mining and Refining Co. will be the name of a new company to be formed by several companies with holdings in the Alberta, Canada, tar sands area. Large-scale production reportedly canot be started until there is a firm market for at least 25,000 bpd.

Companies forming the new organization are West Canadian Oil and Gas, Ltd., Canadian Atlantic Oil Co., Pacific Petroleums Co., Calvan Consolidated Oil and Gas Co., New Continnental of Canada, Charter Oil Co., Canadian Coliers Co., Amurex Development Co., and Calumet Creek Oil Co.

Standard Oil Co. of California has completed arrangements for a Hawaiian refinery, and reports the plant should be in operation by late 1960 or early 1961. Last step in the plans were completed when water rights amounting to 7-million gallons a day were secured to maintain the projected 35,000-bpd plant.

The $40-million refinery will be developed on the island of Oahu, just a few miles from Pearl Harbor, on a 210-acre site. Preliminary design for the refinery is now underway, with Hawaiian Dredging and Construction Co. and Bechtel Corp. handling process equipment. Crude oil will be received through a 10,000-foot offshore pipe line.

E. I. du Pont de Nemours & Co. is planing a major project to expand product development and technical service facilities for tetraethyl lead and other petroleum additives at Deepwater Point, N. J. Construction has begun, and completion is scheduled for mid-1959.

Plans call for construction of two new wings on the existing main laboratory building and a new garage for the division's Road Test laboratory, where fuels and additives are tested in late model automobiles.

Escambia Chemical Corp.'s new methanol plant near Pensacola, Fla., is now on stream. This is Escambia's third production unit in the Pensacola area and the first for the company in the Southeast.

The company's nitrogen plant began production in 1955 as the first plant of its type in the area. It produces anhydrous ammonia, fertilizer nitrating solutions and prilled ammonium nitrate.

This third plant has a design capacity of 44,000 gallons per day.

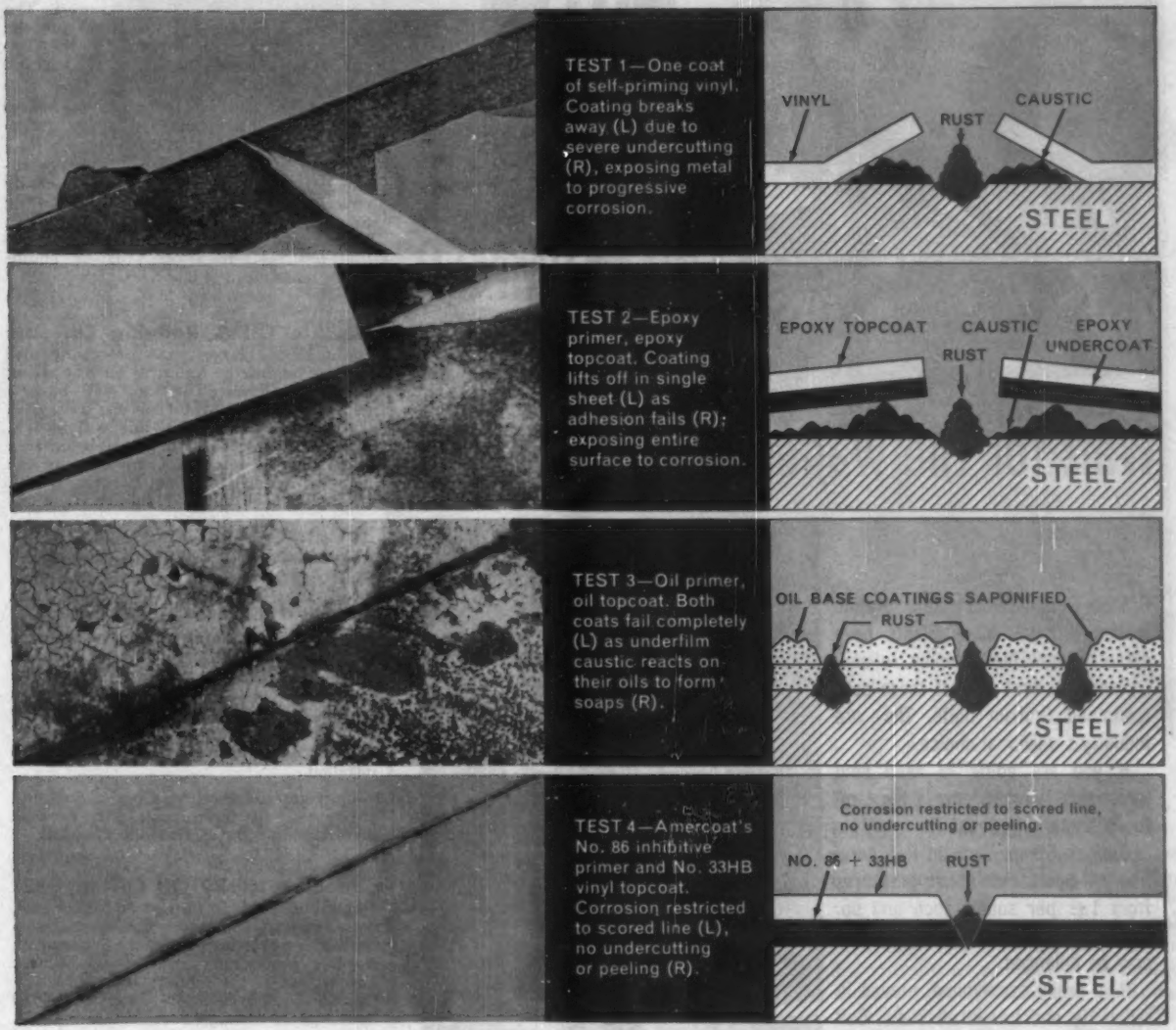
Standard-Vacuum Oil Co. will build a second Australian refinery on a 500-acre site at St. Vincent Gulf, 20 miles south of Adelaide. A crude capacity of 35,000 bpd is planned. Preliminary engineering plans are underway for the project.

Mitsui Petrochemical Industries, Ltd., and **Sumitomo Chemical Co., Ltd.,** have placed two major ethylene plants on stream in Japan. A 20,000 metric ton per year unit for Mitsui Petrochemical Industries, Ltd., is located at Iwakuni City near Hiroshima, Japan.

The other ethyleen plant is a 12,000 metric ton per year unit for Sumitomo Chemical Co., Ltd., at Niihama on the Island of Shikoku, south of Japan's Inland Sea. Both plants went into operation smoothly and within a few days after re-

PUZZLED ABOUT PRIMERS?

Here are tests you can duplicate


TEST 1—One coat of self-priming vinyl. Coating breaks away (L) due to severe undercutting (R), exposing metal to progressive corrosion.
VINYL
RUST
CAUSTIC
STEEL
TEST 2—Epoxy primer, epoxy topcoat. Coating lifts off in single sheet (L) as adhesion fails (R); exposing entire surface to corrosion.
EPOXY TOPCOAT
CAUSTIC
RUST
EPOXY UNDERCOAT
STEEL
TEST 3—Oil primer, oil topcoat. Both coats fail completely (L) as underfilm caustic reacts on their oils to form soaps (R).
OIL BASE COATINGS SAPONIFIED
RUST
STEEL
TEST 4—Amercoat's No. 86 inhibitive primer and No. 33HB vinyl topcoat. Corrosion restricted to scored line (L), no undercutting or peeling (R).
Corrosion restricted to scored line, no undercutting or peeling.
NO. 86 + 33HB
RUST
STEEL

The purpose of these accelerated tests is to show what happens when various types of coatings are exposed to a typical corrosive environment. Four clean steel panels, free from mill scale and rust, were coated with different combinations of primers and topcoats. Each was scribed to bare metal and immersed in salt water in the presence of free oxygen, for two weeks.

As caustic deposits formed over cathodic areas of the steel in tests 1, 2 and 3, failure occurred in three ways. The vinyl, though not directly attacked, was undercut as caustic spread beneath the film and destroyed adhesion. The epoxy coating, known for critical adhesion to smooth metal, proved impervious to caustic attack. It was, however, lifted in its entirety as moisture spread beneath the surface. The entire oil paint film was quickly penetrated by the salt solution, creating widespread corrosion and caustic formation. The caustic then reacted with the oil to saponify the film.

In the fourth test the corrosion was limited to the score mark. Reason: Amercoat No. 86 Primer resists undercutting and adheres tenaciously, inhibiting electrolytic corrosive action.

The conclusions are clear. To provide long term protection in corrosive service, start with Amercoat No. 86 Primer, which provides a sound and lasting base for quality topcoats such as Amercoat No. 33HB.

Write today for complete data on Amercoat No. 86, and have the details on hand when planning your next important coating job.

Amercoat CORPORATION
109A Dept. VE
4809 Firestone Blvd., South Gate, Calif.

For more data on advertised products, use Readers' Service Cards, last page.

HOW WILL YOU GET COLD WATER THIS SUMMER?

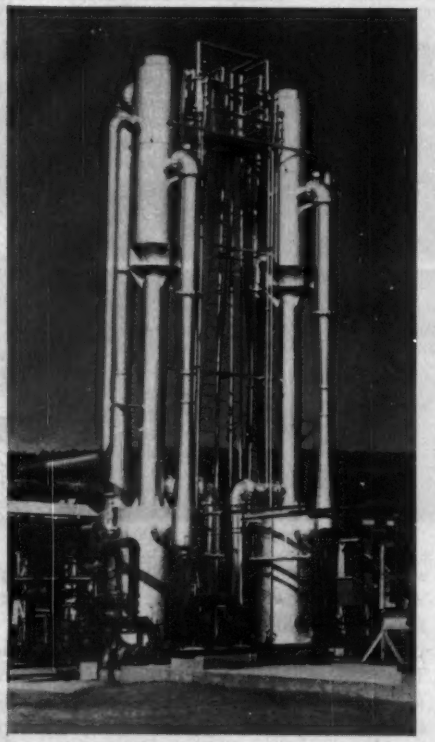
Wait for the wagon? *We hope not!*

Graham Steam Vacuum Refrigeration makes it easy. Many plants have come to know the economy, reliability and low first cost of these self-contained Graham units. They are industry's universal choice.

If you are going to need cold water this summer, now is the time to do something about it.

Graham Steam Vacuum Refrigeration will operate on steam pressures from 1# per square inch and up. Water versus steam requirements may be balanced.

It is really economical, proved in reliability and low in all costs. Call on us for an estimate without obligation. Or write for our Bulletin 60-A.



600 ton Graham Twin Element Steam Vacuum Refrigeration Unit selected by a well known pharmaceutical manufacturer in Pennsylvania

Graham

GRAHAM MANUFACTURING CO., INC.

415 LEXINGTON AVE., NEW YORK 17, N. Y.

Offices in principal cities and Canada

Heliflow Corporation

Who's Building . . .

ceiving feed stock were producing the designed high purity products.

The Mitsui ethylene plant obtains its feed stock from a nearby refinery and the other ethylene product is used for making polyethylene by the Ziegler process. The Sumitomo ethylene also is used for the production by polyethylene by the Imperial Chemical Industries, Ltd., high pressure process.

A phenol and acetone plant for Mitsui Petrochemical is expected to go on stream at Iwakuni City shortly.

These plants are among eight petrochemical plants in Japan either recently completed or presently under design by Stone & Webster Engineering Corp. In carrying out this work, maximum utilization has been made of Japanese equipment, materials and labor.

Humble Oil & Refining Co. plans to build the largest gas processing and cycling plant in America on the King Ranch in Texas. The unit will have a capacity of 750 MMcf of gas a day. A 30-inch gas transmission line will be laid from Southwest Texas to the Houston area as part of the project. Completion of the plant is expected in about two years, with construction costing $77 million.

Mitsubishi Oil Co., Ltd. has marked its entrance into the petrochemical field by installing the first Udex unit in Japan at Kawasaki City.

Startup of this unit, which has a design capacity of 750 bpsd to produce benzene, toluene and xylenes, followed by less than two weeks the placing into operation of a second UOP Platforming unit at the Mitsubishi plant.

A 12,500-bpsd Unifining unit was also installed.

Universal Oil Products Co. designed and engineered all three units and licensed them through Japan Gasoline Co., Ltd.

Canadian Husky Oil Co. may build a catalytic cracking unit at its Moose Jaw, Saskatchewan, refinery. The $4-million project would increase the company's gasoline production. Process equipment now in use at the refinery includes a visbreaker (1,300 bpd), a Catformer (650 bpd), and a Deisulformer (1,000 bpd).

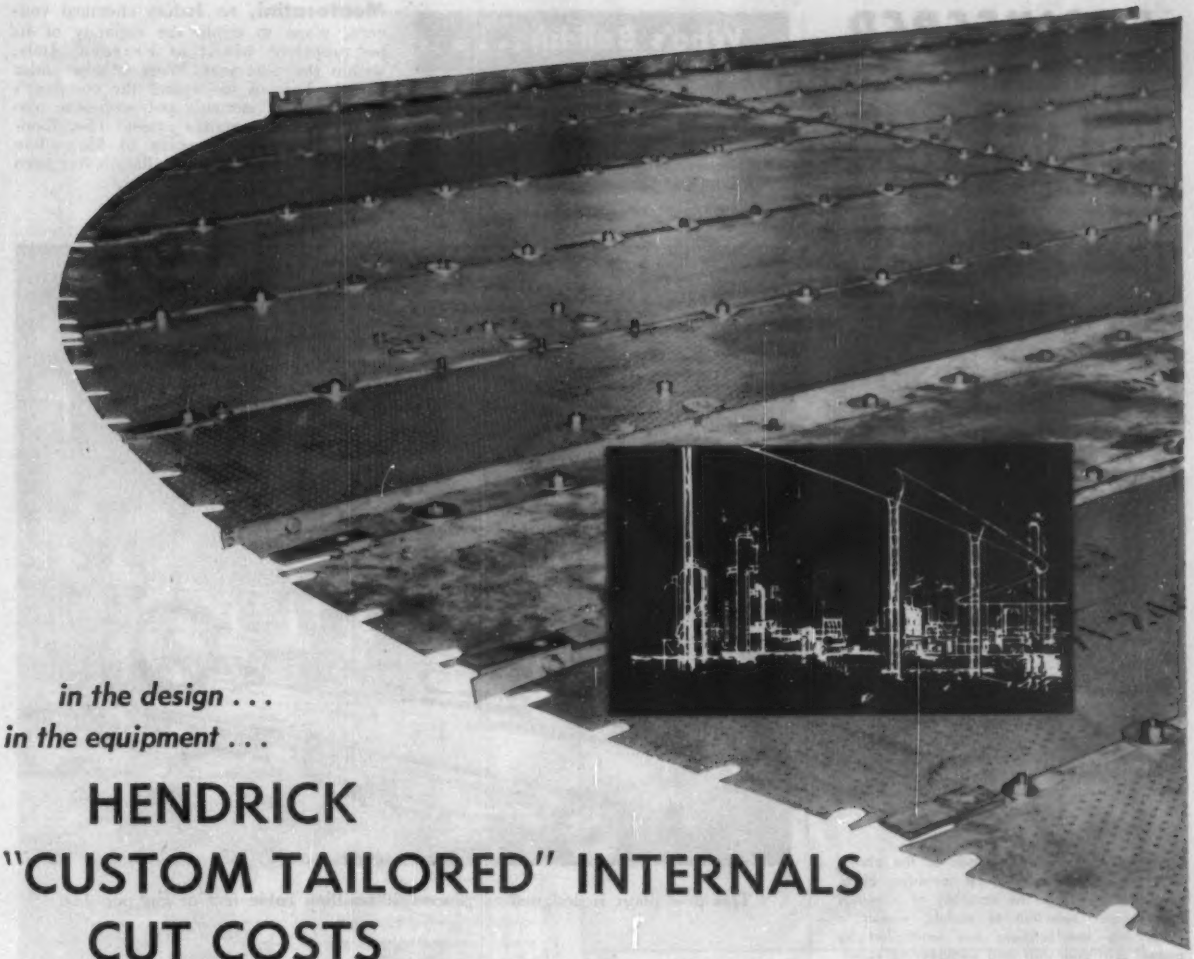
Allied Chemical & Dye Corp.'s Nitrogen division will increase the capacity of its South Point, Ohio plant from 80,000 tons a year to 110,000 tons a year. Completion is scheduled for late 1958.

D-X Sunray Oil Co. has completed a 6,000-barrel Unifining unit and revamp of a vacuum unit at its 43,000-bpd Duncan, Okla., refinery.

Capacity of the 16,000-bpd vacuum unit has been increased slightly. It will now recover a greater percentage of light hydrocarbons.

The Unifining unit is part of an overall expansion program at the Duncan plant and the 75,000-bpd D-X Sunray plant in Tulsa, where units now getting finishing touches are a 20,000-bpd naphtha Unifiner, a 12,000-bpd Platformer with re-

For more data on advertised products, use Readers' Service Cards, last page.



in the design . . .
in the equipment . . .

HENDRICK "CUSTOM TAILORED" INTERNALS CUT COSTS

Here's how you save when you use Hendrick perforated metal plate

HENDRICK PLATE HAS CLEAN CUT PERFORATIONS. Decks are completely fabricated from Hendrick's own perforated metal to your selected hole size and spacing and—straight or indented. This assures clean cut perforations, uniformity of mesh and long service life.

HENDRICK COLUMN INTERNALS HAVE GREATER CAPACITY. Hendrick perforated tray assemblies have greater capacity than trays of non-perforated design and equal diameter. You save in the diameter of columns required for a specified process capacity. And—complete Hendrick assemblies *cost* less.

HENDRICK HAS THE CORROSION-RESISTANT METALS YOU NEED. A Hendrick tray perforated from stainless steel, monel, copper, aluminum, or many other metals, can greatly reduce high cleaning and replacement costs caused by fouling and corrosion.

Here's how you save through Hendrick "Custom-Tailoring"

Once you specify Hendrick perforated metal decks for your distillation columns, Hendrick design engineers go to work with the column manufacturer. They are often able to suggest invaluable design improvements. Then, on your approval, Hendrick "custom-tailors" perforated metal in your choice of commercially rolled metals and gauges to meet the most detailed specifications. Finally, Hendrick engineers test every component that goes into the fabrication of your "custom-made" perforated metal column. The result is "custom-tailoring" that cuts the cost of installing, maintaining, and replacing column internals.

For more detailed information, mail the coupon below. A Hendrick representative will be happy to meet you.

HENDRICK
MANUFACTURING COMPANY

Perforated Metal • Perforated Metal Screens • Wedge-Slot and Hendrick Wedge Wire Screens • Architectural Grilles • Mitco Open Steel Flooring • Shur-Site Treads • Armorgrids • Hendrick Hydro-Dehazer • Distillation Column Internals.

HENDRICK MANUFACTURING COMPANY
36 Dundaff Street, Carbondale, Penna.

Gentlemen:
☐ Please send me FREE literature
☐ Send representative

Name_____ Title_____
Company_____
Address_____
City_____ Zone____ State_____

For more data on advertised products, use Readers' Service Cards, last page.

ENGINEERED
CRAFTSMANSHIP KEEPS
CLEVELAND WIRE SCREENS
'way out in front

JOB CONTROL RECORD

TIGHTNESS OF WEAVE		
ACCURACY OF CRIMP		
QUALITY OF METAL		
UNIFORMITY OF WEAVE		
WIRE THICKNESS		
SPECIFIED SIZE		
FLEXIBILITY		
DURABILITY		

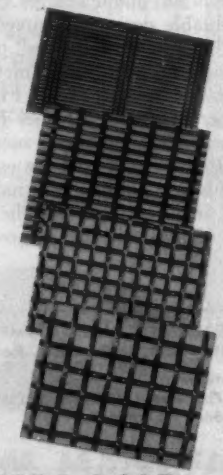
TESTED AND APPROVED BY_____

THE CLEVELAND WIRE CLOTH & MFG. CO.

Successful processing depends on the ability of the wire screens to resist corrosion, abrasion and blinding. The accuracy of openings and proper selection of metals, woven to exact job specifications are controlled by expert craftsmanship and engineering supervision.

Filter segments and strainer elements can be fabricated to your individual job requirements. A wide range of weaves in all commercial metals and alloys such as stainless steel, monel, silver and copper are available.

We maintain a complete sample service department to take the guess work out of job specifications. Complete and descriptive bulletin files are available. Write or phone Diamond 1-1832.



Reference:
Purchasing Directory
Thomas' Register
Conover-Mast
MacRae's Blue Book

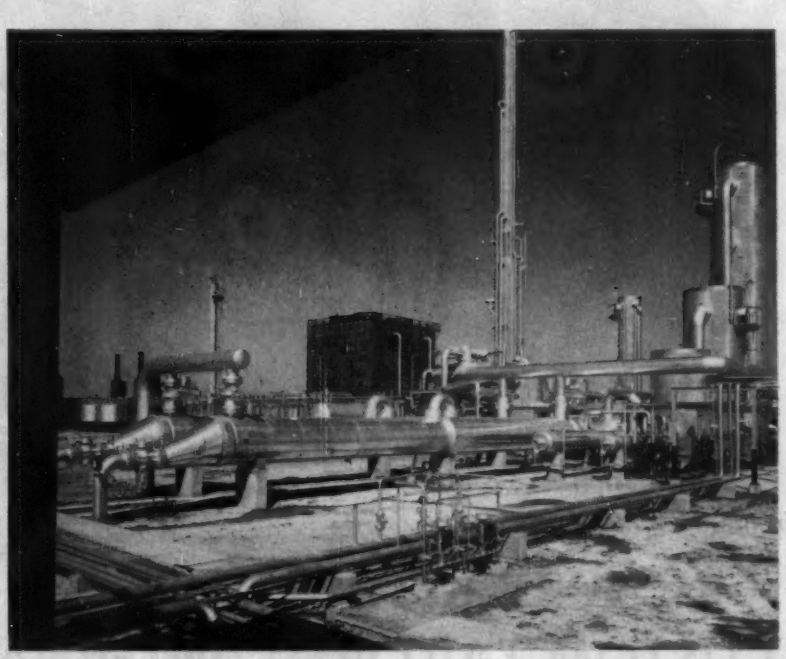
Petroleum Refiner Catolog

The CLEVELAND WIRE CLOTH & MFG. Co.
3571 E. 78th STREET - CLEVELAND 5, OHIO

Who's Building . . .

run column, a 1,417-bpd liquefied petroleum gas recovery unit, a 2,450-bpd butane isomerization unit, and a 2,470-bpd HF alkylation unit. The Refinery Engineering Co., handled construction.

Montecatini, an Italian chemical concern, plans to triple the capacity of its polypropylene plant at Ferrara, Italy, within the next year. Work is now under way at Ferrara to expand the company's production of isotactic polypropylene materials from the plant's present 15-million-pound annual capacity to 45 million pounds. The Ferrara installation has been operating since last September.



This new plant is designed to process 300-million cubic feet of gas per day.

New Gas Plant Is Louisiana's Largest

Runnels Gas Products Corp. and Texas Gas Exploration Corp. have completed the largest gas processing plant in Louisiana. Dedication ceremonies were held in Eunice, La., April 23. The Eunice extraction plant is jointly owned by the two companies and is operated by Runnels, the wholly owned subsidiary of Union Oil and Gas Corp. of La.

The plant is located on the Texas Gas Transmission line in Acadia Parish 6 miles west of Eunice, and 20 miles northwest of Crowley, La. It is designed to process 300 million cubic feet of gas per day, and to extract 95 percent of the propane, 99 percent of the butanes and essentially all of the natural gasoline contained in the gas.

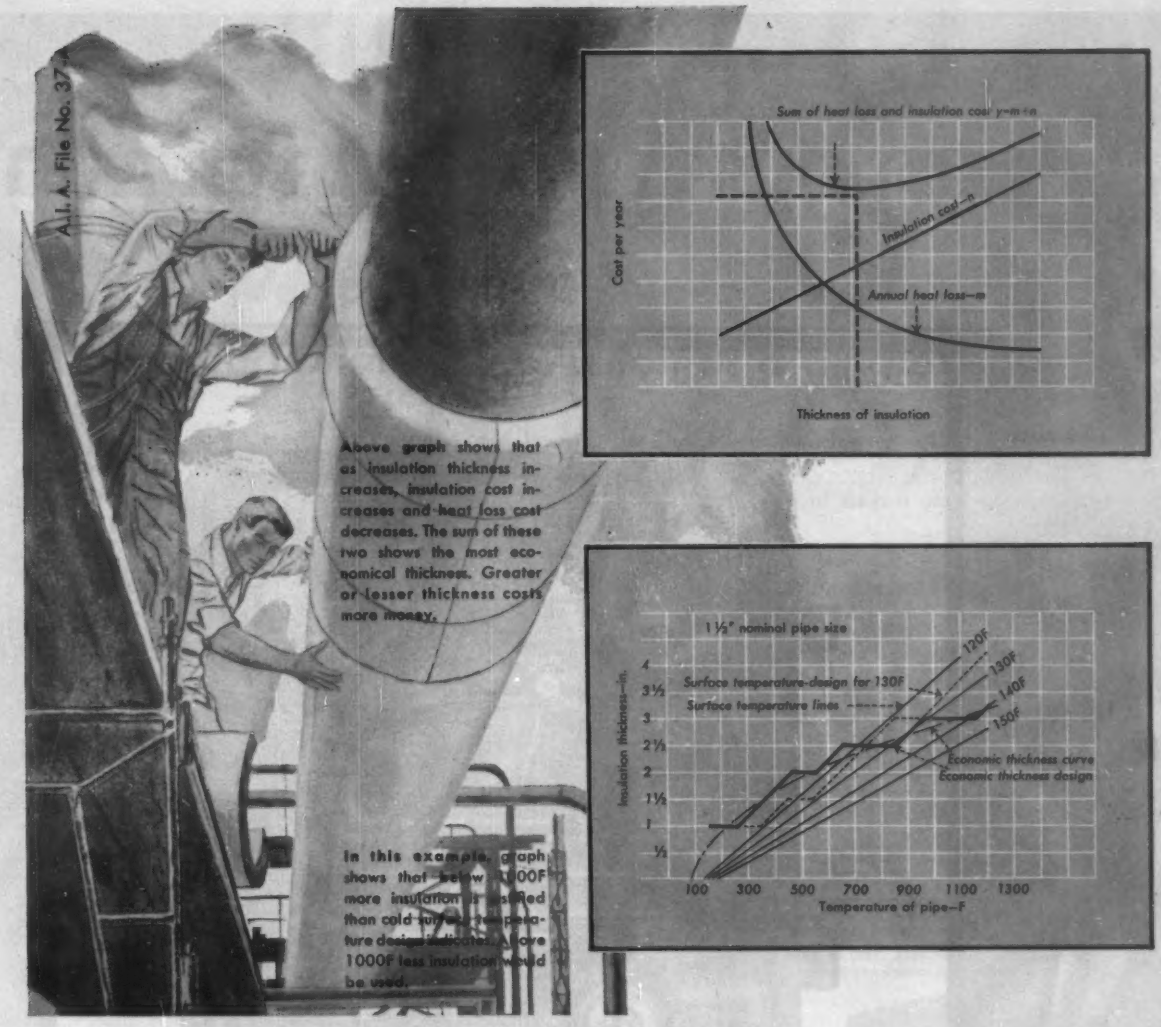
The production each day of approximately 2,450 barrels of propane will be used primarily for domestic consumption; 650 barrels of isobutane will be feed stock for high octane number aviation gasoline; 550 barrels of normal butane will be used in the manufacture of butadiene and 1,350 barrels of natural gasoline will be used in the preparation of motor fuel gasoline.

The desired products are extracted from the incoming gas stream by chilling it to sub-zero temperatures and flowing it through an adsorption tower where it is contacted with an extremely light absorption oil. The stripped gas leaving the top of the absorber is returned to the gas transmission line. The absorption oil containing the extracted products flows from the bottom of the absorber through a series of heat exchangers and towers where the individual products are separated and sent to storage. The plant storage tanks have a capacity of 25,000 barrels, equivalent to five days production. The Fluor Corporation, Ltd. designed and constructed the plant.

A railroad siding and loading rack at Unatex, Louisiana, located on the Missouri Pacific Railroad near the plant, have facilities to load 60 tank cars simultaneously. There is sufficient trackage for storing a maximum of 75 tanks cars. Truck loading docks exist at the same site where eight transport trucks can be loaded at the same time.

Aurora Gasoline Co. is building an 18,000-bpd vacuum unit, scheduled to go in soon at its 47,000-bpd Detroit refinery. Yields will include vacuum-reduced flux oil and a composite optimum-grade F.C.C. gas-oil charge stock.

The unit will incorporate a maximum of steam generation, convert heavy bot-



"COLD SURFACE" CRITERION WASTES MONEY!

How J-M engineers determine economic insulation thickness

to give you more for your insulation dollar

OVER-ALL cost of the operation should always be the determining factor in selecting insulation thickness. Yet, millions of dollars have been wasted because of rigid adherence to the cold surface temperature method. When Johns-Manville insulation is applied, J-M engineers carefully determine which thickness will provide the greatest operational savings. And this "economic thickness" is usually more (or less) than the cold surface method indicates.

Here's how it works. The annual cost of the heat loss through the insulation is plotted for various thicknesses. Also plotted is the annual cost of insulation. A third curve is then drawn as the sum of heat loss and insulation cost. The economical thickness is found where this third curve reaches its lowest point.

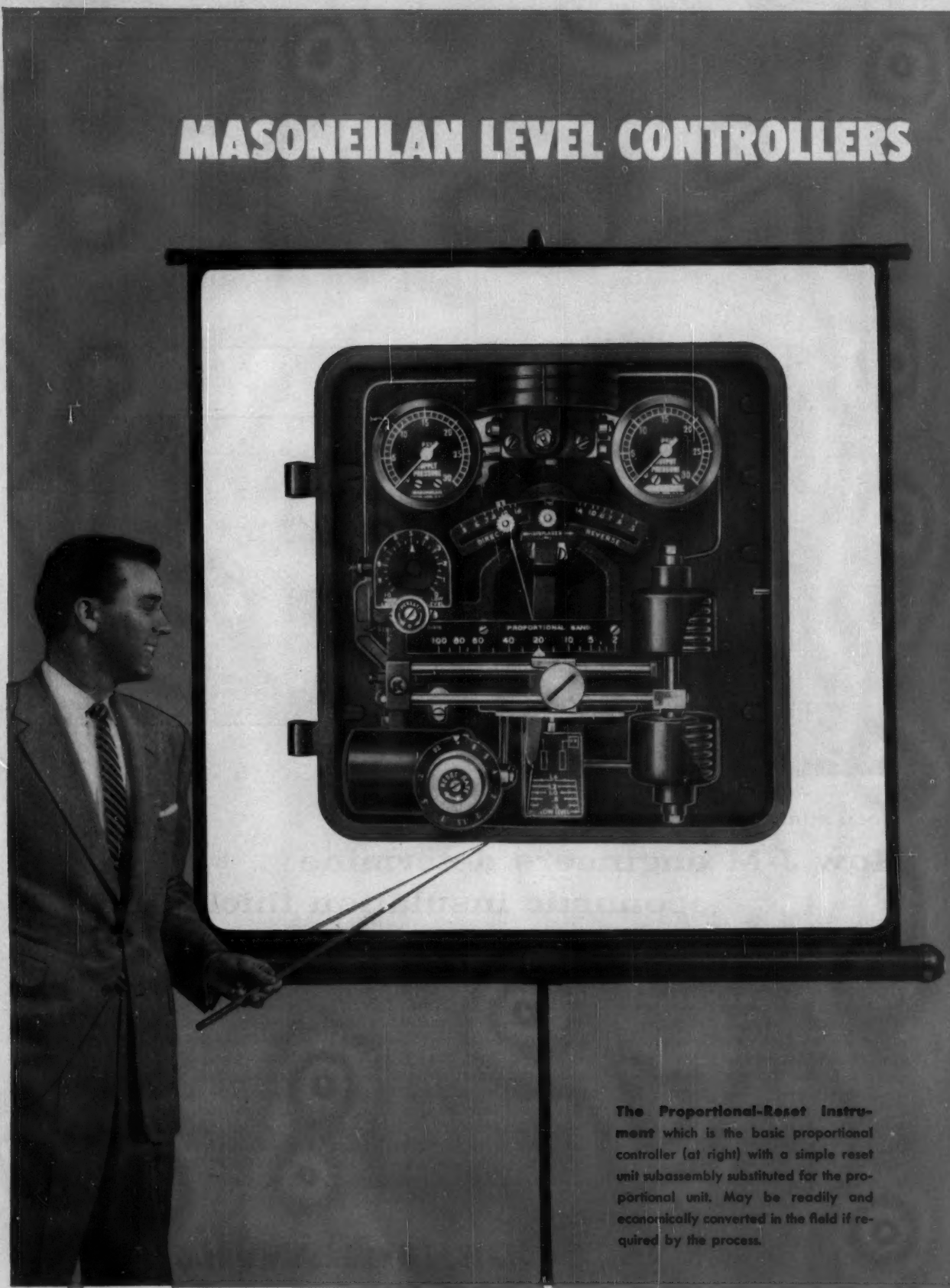
To arrive at the above figures in a given instance requires the following: 1. Cost of heat production per million Btu; 2. Rate of heat loss through insulation in Btu per unit area per hr; 3. Annual hours of operation; 4. Applied cost of insulation per unit area; 5. Rate of amortization and required return on the insulation investment cost. Items 2 and 4 are available from the insulation manufacturer; others are normally supplied by the plant engineer.

For more complete information, call or write Johns-Manville, Box 14, New York 16, New York. In Canada, Port Credit, Ontario. Ask for reprint of technical article "Select Economic Insulation Thickness."

JOHNS-MANVILLE

JOHNS-MANVILLE J-M PRODUCTS

MASONEILAN LEVEL CONTROLLERS



The Proportional-Reset Instrument which is the basic proportional controller (at right) with a simple reset unit subassembly substituted for the proportional unit. May be readily and economically converted in the field if required by the process.

DESIGNED FOR SPECIAL APPLICATIONS, TOO!

Versatile 12000 Series Provides Proportional-Reset Action in a Single Case

In addition to meeting all usual liquid level control requirements, the Mason-Neilan design provides for those few special applications where proportional reset action is advantageous, such as . . .

Precise Control — in, for example, short zone, subcooling type feedwater heaters

Wide Proportional Band — without change of control mechanism

Maintaining Accurate Mean Level — for maximum surge capacity

Moreover this reset action is available with the standard instrument — either the single unit or in the duplex type, which may include a transmitter or other controller.

The advantages of such a one-case controller include:

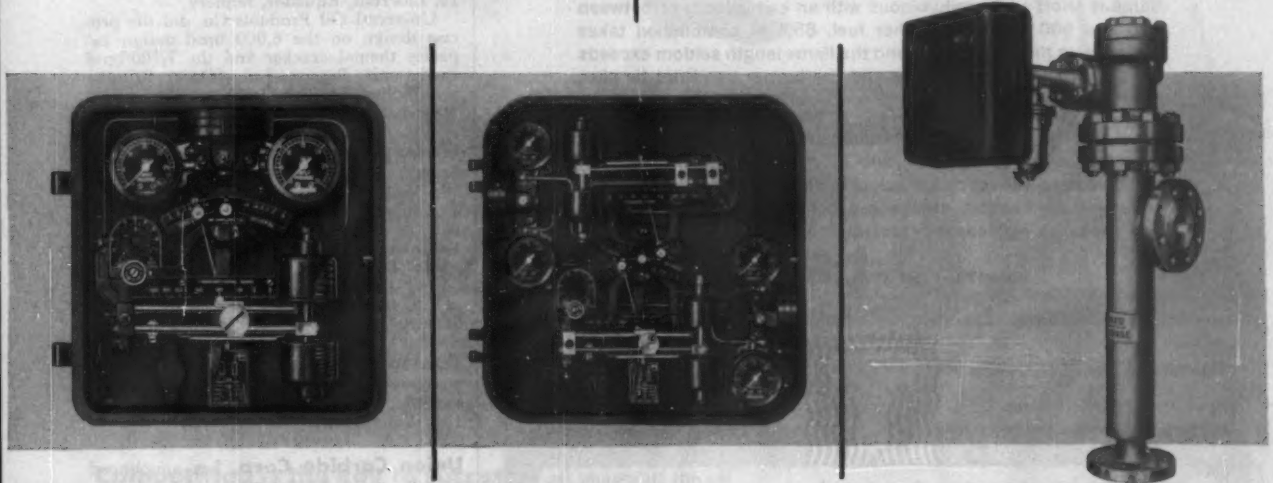
- *Lower Original Cost*
- *A Single, Simple Pneumatic System*
- *Compactness*
- *Easier Start-up and Adjustment*
- *Simpler Installation and Servicing*

Only Masoneilan 12000 Series offers these advantages. It will pay you to get the whole story. Complete, detailed catalog will be sent on request. Ask your nearest representative or write

MASON-NEILAN
Division of Worthington Corporation
51 NAHATAN STREET, NORWOOD, MASSACHUSETTS

District Offices or Distributors in Principal U. S. Cities

In Canada — Mason-Neilan Regulator Co., Ltd. — Brantford, Montreal, Toronto
European Manufacturing Associates
Crosby Valve & Engineering Co., Ltd., Wembley, Middlesex, England
Worthington, Paris, France
Worthington Gesellschaft M.B.H., Hamburg, Germany
Worthington SIPEC, Milan, Italy
Distributors in many other overseas countries



The Basic Proportional Controller satisfies the vast majority of level control applications. Available also with Pneumatic Set and for Differential Gap control.

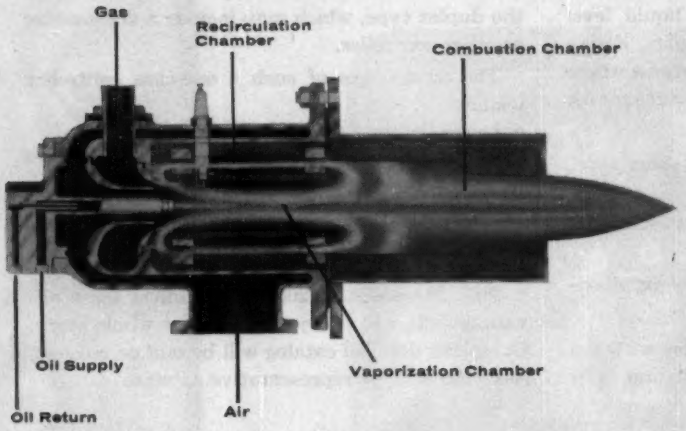
The Duplex Controller combines a controller and transmitter (or two controllers) — actuated by a single displacer and torque tube. It is contained in a single larger case.

12000 Series Controllers are available in a wide variety of mountings and connections; level ranges; pressure and temperature ratings — types for all applications.

For more data on advertised products, use Readers' Service Cards, last page.

THERMAL'S COMBINATION GAS-OIL BURNERS

the flame is the same...
with **OIL** *or* **GAS**



This versatile burner retains its high velocity combustion characteristics whether the fuel used is distillate oil or gas. The flame is short and non-luminous with an exit velocity of between 300 and 500 ft/sec. On either fuel, 85% of combustion takes place within the burner itself and the flame length seldom exceeds 1 ft. Switching fuels is simple and the burner need not be shut off during the changeover.

THERMAL combination burners provide high convection heat transfer for furnaces, dryers and air heaters and tempering air can be added without creating soot or smoke. Special applications include ladle heating, submerged combustion, skelp furnaces and packaged high capacity steam generators.

WRITE FOR BULLETIN #109

OTHER THERMAL PRODUCTS & SERVICES

Gas & Oil Burners • Heat Exchangers • Submerged Combustion • Air Heaters • Gas Generators • Combustion and Heat Transfer Engineering.

THERMAL
Thermal Research & Engineering Corp.
CONSHOHOCKEN • PENNSYLVANIA
REPRESENTATIVES IN PRINCIPAL CITIES

Who's Building...

toms into an improved charge stock for the catalytic cracker, and increase the yield of high-octane gasoline. It will also produce additional quantities of asphalt products.

Completion is scheduled for early in 1959. The Refinery Engineering Co. will design and engineer the project.

Scholven-Chemie A.G. plans to build a polyethylene plant at Gelsenkirchen-Buer, Germany. The plant's initial capacity will be 6,000 tons-per-year.

Omnium Francais De Petroles is considering the erection of a new refinery in France to process crude oil from French Sahara. It will be located in Burgundy, near Chalon-Sursaone and is presently expected to have a design capacity of 75,000 bpsd with provisions for an easy extension to 100,000 bpsd.

Crude oil will be supplied through a 22-inch pipeline connecting the Mediterranean coast (Marseilles-l'Avera) to the refinery and to the Rhine valley (Strasburg).

The new refinery will produce LPG, gasoline, kerosene, diesel oils and fuel oils for the eastern-center-part of the country.

Kolker Chemical Corp. is now producing anhydrous methyl chloride at its new plant at Newark, N. J. The capacity is estimated at 4,500 tons annually.

Poland has modernized and reconverted its refinery at Glinnik Mariampolski. Its capacity is 3,200 bpd. Construction of a new refinery is being considered for Pomerania (district of Konin).

Anglo-Equadorian Oilfields, Ltd., has almost completed work on its thermal cracking and crude distillation units at the La Libertad, Equador, refinery.

Universal Oil Products Co. did the process design on the 6,000 bpsd design capacity themal cracker and the 7,700-bpsd crude unit. Procon, Ltd. (Great Britain) is handling the detailed engineering and construction.

Goodyear Tire & Rubber Co. plans a $9 million plant at Apple Grove, W. Va., to manufacture a new plastic. The plant, located on a 300-acre tract, will be a five-story structure occupying approximately 100,000 square feet of floor space. Engineering plans are being completed and the facility is expected to be in full production by early spring of next year.

Coastal Chemical Corp. has started construction of an ammonia plant at Pascagoula, Miss. It will have a capacity of 150 tons per day.

Union Carbide Corp. has announced it will spend $150-million on new construction this year. Among Carbides major projects are (1) a new chemicals plant in Putnam County, W. Va., to produce ethylene oxide, ethanol and isoproponol for further processing at the corporations South Charleston and Institute, W. Va., facilities, (2) facilities for producing polyethylene resins at Whiting, Ind., and Seadrift, Texas, (3) a plant at Marietta, Ohio, to produce liquid epoxy resins, (4)

For more data on advertised products, use Readers' Service Cards, last page.

Who says there's not enough competition in the Oil Industry?

PRODUCTION: "I compete against 15,000 other independent oil producers to keep America supplied with enough oil to meet our future needs."

RESEARCH: "I compete with thousands of scientists from scores of other oil companies to create new and better products for consumers."

REFINING: "Competition in my field keeps the top refining company in the United States down to only 10.4% of the total refinery output."

MARKETING: "And, of course, everyone knows about the intense competition in my end of the oil business—America's more than 180,000 service stations."

Competition is the key to success in all phases of the oil industry. Large, medium and small oil companies compete to supply the products that fuel our nation's economy.

All this competition has one all-important result: Americans enjoy the widest selection of high-quality oil products at the lowest prices anywhere in the world.

For more valuable information about your industry clip and mail this coupon.

American Petroleum Institute, Dept. G
50 W. 50th Street, New York 20, N. Y.

Please send me your FREE booklets on the oil industry.

NAME_____

ADDRESS_____

CITY_____ ZONE____ STATE_____

For more data on advertised products, use Readers' Service Cards, last page.

There's **extra** metal for **extra** strength in

W-S 150 lb. STAINLESS STEEL FITTINGS

Exceptional strength and perfect alignment are features you can rely on in W-S 150 lb. Stainless Steel Fittings. Because they resist corrosion, stand up to extreme heat and cold, they're ideal fittings to safeguard the processes of petroleum, chemical, food and other process industries.

Specify W-S screw-end and socket welding fittings. Available in sizes ⅛" to 4"...in every type you may need. Materials: Stainless Steel types 304 and 316. ASTM-A-182, Grade F-304, F-316 for forged fittings. ASTM-A-296, Grade CF-8, CF-8M for precision cast fittings.

Forge and Fittings Division manufactures a full line of high quality fittings, unions and couplets...in carbon, stainless and alloy steels. For information about them and for your commercial forging and die casting requirements, write to Forge and Fittings Division, H. K. Porter Company, Inc., Box 95, Roselle, N. J.

H. K. PORTER COMPANY, INC.

FORGE AND FITTINGS DIVISION

W-S Fittings Works, Roselle, N.J. • Cleveland Forge Works, Cleveland 4, Ohio
Stainless Steel Works, Duncannon, Pa. • Cleveland Die Cast Works, Cleveland 4, Ohio

Who's Building...

a plant to produce flourocarbon products at Institute, W. Va., (5) expansion of three large liquid oxygen, nitrogen and argon plants at East Chicago, Ind.; Ashtabula, Ohio and Fontana, Calif.

Continental Oil Co. plans to build a 52,000-bpd crude oil refinery at Lake Charles, La. The Babcock & Wilcox Co. will construct the plant.

B&W officials said that the unit has a special design feature which allows it to operate initially with conventional fuel and then switch over to utilize hot gas turbine exhaust instead of air for combustion. This arrangement will enable the oil company to employ a gas turbine at the refinery and reclaim and use the tremendous amount of heat, which otherwise would be wasted, in the exhaust gases.

Polands Kozen metallurgical Mostostal will build a petrochemical plant at Osvlecin to make synthetic rubber. The plant capacity has not been disclosed.

Bahrain Petroleum Co. will install a UOP platforming unit with a capacity of 11,000 bpd. It is reportedly the first such unit in the Middle East.

Brazil Petrobras is planning to build a 25,000-bpd refinery at Rio Grande do Sul. No date for construction to begin has been announced.

Brazil is reportedly planning to step up its refining facilities. Capacity of the country's oil refining facilities will rise to 330,000 bpd by 1960, according to the Brazilian government. In 1955 the output was 130,000 bpd.

Phillips Petroleum Co. and **Pacific Petroleums, Ltd.,** have completed a 4,000-bpd plant near Taylor, British Columbia. The plant converts natural gas liquids into motor and diesel fuel and separates liquified petroleum gas. Phillips also has a half interest in a 2,500-bpd crude oil refinery at Dawson Creek, B. C.

National Petro-Chemicals Corp. intends to quit the site previously announced for its $20-million polyethylene plant because of title defects on the 203-acre tract in the Phillips Chemical Center. Negotiations are under way for another site in the 1,000-acre chemical center tract near Houston.

Hercules Powder Co. is planning a plant to produce solid propellents for long range missles. The unit will be built on a 500-acre site near Hercules' Bacchus, Utah, explosives plant, and will operate under guidance of the Chemical Production division.

Rock Island Refining Corp. has gone on stream with a second Unifining unit at its Indianapolis refinery. The electronically controlled unit has a charge capacity of 5,000 bpd of straight-run and visbreaker gasoline. Of this, 3,000 bpd is charged to the Platformer, the capacity of which has been increased from the original 2,400-bpd design.

The Unifiner has a stabilizer column and a splitter column. Bottoms of the

For more data on advertised products, use Readers' Service Cards, last page.

Buying Heat Exchanger Tube?

If you are, then naturally you're looking for top value for your tubing dollars. That's exactly what you'll get when you specify heat exchanger tubes made the Tubemanship way by Wolverine. You can specify both prime surface tubing or Wolverine Trufin®—the integrally finned heat exchanger tube that boosts shell side heat transfer surface in both condensers and heat exchangers. Each is available in a wide range of types, alloys and sizes. Wolverine Tube's complete heat exchanger tube lineup is pictured on the following two pages. Look them over, and then specify the type—or types—you need. You'll find that because of Tubemanship—***there is a difference in tubing.***

CALUMET & HECLA, INC.
CALUMET DIVISION
URANIUM DIVISION
GOODMAN LUMBER DIVISION
WOLVERINE TUBE DIVISION

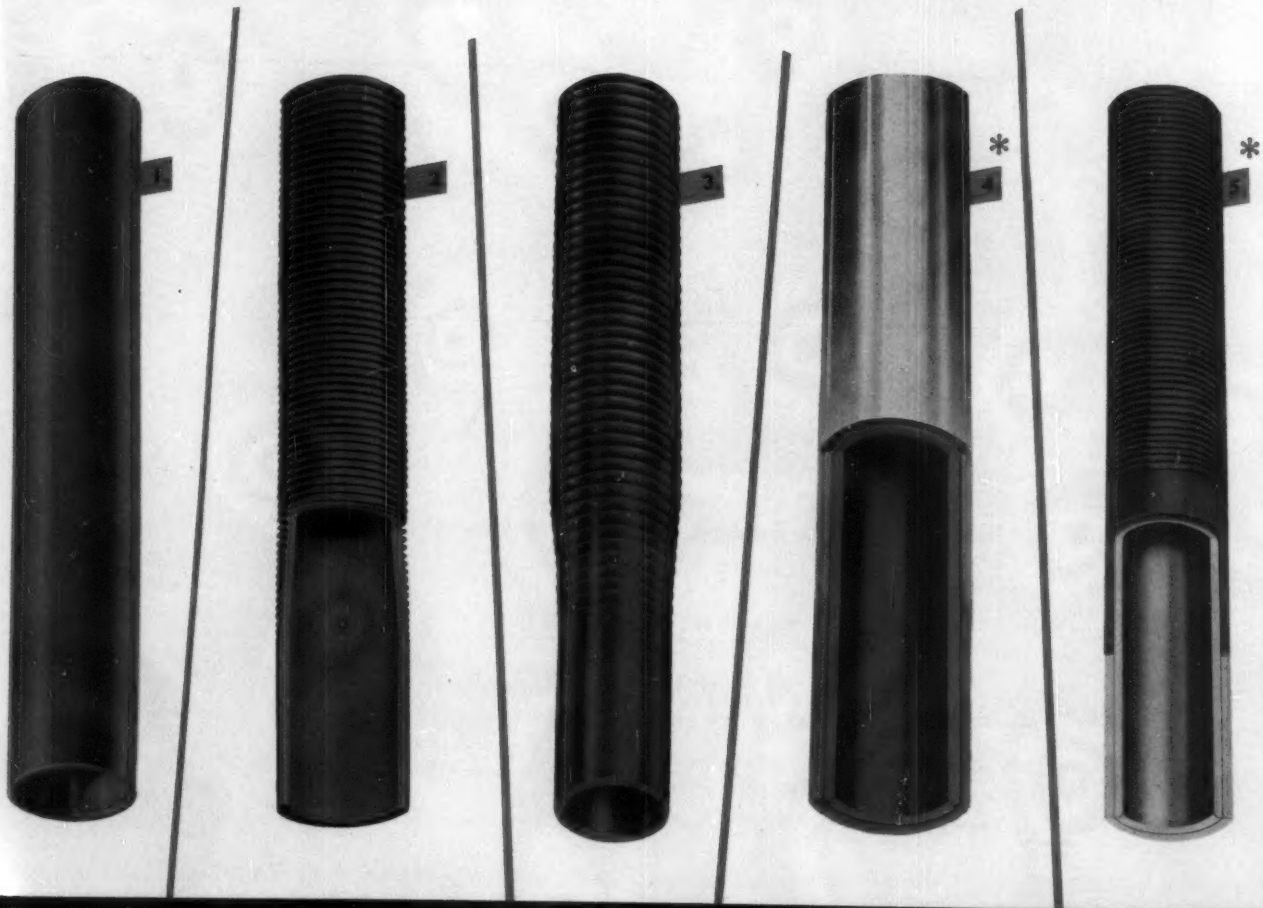
In Canada:
CALUMET & HECLA OF CANADA LIMITED
WOLVERINE TUBE DIVISION
CANADA VULCANIZER & EQUIPMENT CO. LTD.
UNIFIN TUBE DIVISION

WOLVERINE TUBE
DIVISION OF
CALUMET & HECLA, INC.
17236 Southfield Road
Allen Park, Michigan
Manufacturers of Quality-Controlled Tubing and Extruded Aluminum Shapes

PLANTS IN DETROIT, MICHIGAN AND DECATUR, ALABAMA
SALES OFFICES IN PRINCIPAL CITIES

EXPORT DEPT. 13 E. 40TH ST., NEW YORK 16, N.Y.

WOLVERINE MAKES ALL THESE TUBES

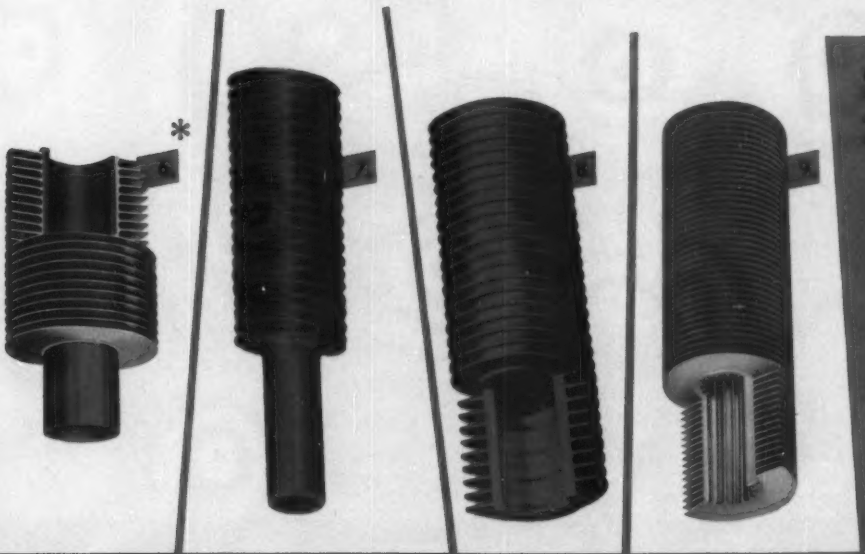


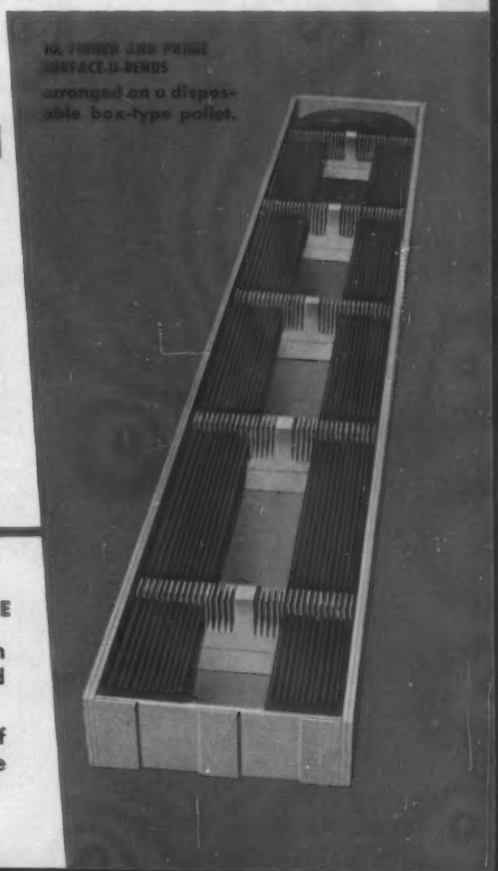
...FOR HEAT EXCHANGE
...FOR CONDENSING

1. PRIME SURFACE TUBE
2. WOLVERINE TRUFIN TYPE S/T
3. WOLVERINE TRUFIN TYPE W/H
4. PRIME SURFACE TUBE—Bi-Metal
5. WOLVERINE TRUFIN—Bi-Metal
6. WOLVERINE TRUFIN TYPE L/C—Bi-Metal
7. WOLVERINE TRUFIN TYPE H/R
8. WOLVERINE TRUFIN TYPE H/A
9. WOLVERINE TRUFIN TYPE I/L

Wolverine Tube believes that to serve an industry well you must know its problems. That's why it maintains an extensive research and development program—from which has come the wide range of heat exchanger tubes illustrated below. From these you can choose tubing that will successfully withstand corrosive attack . . . boost heat transfer capacity . . . or eliminate (with U-Bend tubes) the fabrication and handling problems encountered when working with condenser tubes over 30 feet in length. Any one you specify will serve you well.

Wolverine Trufin is available in Canada through the Unifin Tube Division, London, Ontario.





*Now! BOND-RESISTANCE TESTING FOR BI-METAL TUBE

A new Wolverine Heat Transfer Tester has been developed which accurately measures ***bond-resistance*** of Wolverine Trufin Type L/C and other bi-metal tubes.

Exhaustive tests during manufacture have shown bond resistances of Type L/C to be negligible. This is another step by Wolverine to insure your receiving the highest tubular quality.

FREE ENGINEERING HELP

Skilled engineering help—from men who know tubing and how it can serve you most advantageously—is instantly available to Wolverine customers. If you have a problem concerning heat transfer, corrosion, type of tube to use or what have you—don't hesitate—just call on Wolverine's Field Engineering Service. There is no obligation.

AS NEAR AS YOUR TELEPHONE

Wolverine sales offices are maintained in many cities throughout the United States. You'll find the names and addresses listed in the yellow pages of your telephone directory.

● SALES OFFICES

ALLEN PARK, MICHIGAN
ATLANTA, GEORGIA
BIRMINGHAM, ALABAMA
CHARLOTTE, NORTH CAROLINA
CLEVELAND, OHIO
COLUMBUS, OHIO
DALLAS, TEXAS
DAYTON, OHIO
DECATUR, ALABAMA
DENVER, COLORADO
DETROIT, MICHIGAN
EVANSTON, ILLINOIS
GRAND RAPIDS, MICHIGAN
HOUSTON, TEXAS
JACKSONVILLE BEACH, FLORIDA
KANSAS CITY, MISSOURI
LOUISVILLE, KENTUCKY
LOS ANGELES, CALIFORNIA
MILWAUKEE, WISCONSIN
MINNEAPOLIS, MINNESOTA
MOLINE, ILLINOIS
NEW YORK, NEW YORK
PITTSBURGH, PENNSYLVANIA
PHILADELPHIA, PENNSYLVANIA
PHOENIX, ARIZONA
PROVIDENCE, RHODE ISLAND
ROCHESTER, NEW YORK
SALT LAKE CITY, UTAH
SAN FRANCISCO, CALIFORNIA
ST. LOUIS, MISSOURI
SEATTLE, WASHINGTON
WASHINGTON, D.C.

★ WOLVERINE PLANTS

DETROIT, MICHIGAN
DECATUR, ALABAMA

CALUMET & HECLA, INC.
CALUMET DIVISION
URANIUM DIVISION
WOODMAN LUMBER COMPANY
WOLVERINE TUBE DIVISION

In Canada:
CALUMET & HECLA (CANADA) LIMITED
WOLVERINE TUBE DIVISION
CANADA WOODWORKERS & EQUIPMENTS LTD.
WOLVERINE TUBE DIVISION

WOLVERINE TUBE
DIVISION OF
CALUMET & HECLA, INC.
17236 Southfield Road
Allen Park, Michigan
Manufacturers of Quality Controlled Tubing and Extruded Aluminum Shapes

PLANTS IN DETROIT, MICHIGAN AND DECATUR, ALABAMA. SALES OFFICES IN PRINCIPAL CITIES

EXPORT DEPT. U.E. 40TH ST., NEW YORK 16, N.Y.

MADE IN U.S.A. TO THE STANDARDS OF AMERICAN INDUSTRY

Who's Building. . .

splitter column are sent to the Platformer, and Unifiner stabilized light gasoline from the top is sent to storage. The original Unifining unit is being converted from a visbreaker gasoline treatment unit to production of special naphthas.

Gulf Oil Corp. has placed a new 26,000 bpd Platforming unit on stream at its Philadelphia refinery. This is the second unit of this type for the Philadelphia location. Both units were designed by Universal Oil Products Co. and erected by Procon, Inc.

Allied Chemical & Dye Corp.'s Solvay Process division has completed expansion of its Moundsville, W. Va., plant. Capacity of the plant will be doubled for production of vinyl chloride monomer.

The Sheik of Kuwait opened two new distillation units at Mina al Ahmadi, Kuwait, increasing refinery output to 190,000 bpsd from the previous 30,000 bpsd level. Production will be used mainly to bunker tankers loading crude oil at this Persian Gulf port.

E. I. duPont de Nemours & Co. has placed a new plant on stream for production of a new synthetic rubber at Deepwater Point, N. J.

Witco Chemical Co. has contracted with Scientific Design Co. for the building of a 20-million-pound-per-year high-purity phthalic anhydride plant in Chicago. Completion is scheduled for early 1959.

E. I. duPont de Nemours & Co. will have three production units added to its Repaunco works, Gibbstown, N. J. They are a hydrogen-anhydrous ammonia unit, a aniline facility, and a diphenylamine unit. The Explosives department will operate all three.

Farbwerke Hoechst A.G. is the first German firm to return to Argentina following the return of trademarks and auction of confiscated "enemy property." The company has founded an Argentina firm, Quimica-Hoechst S.A., to produce polyvinyl acetates and its emulsions for the paint, adhesives, and textile industries. The plant is scheduled for completion in mid-1958.

Deere & Co.'s Grand River Chemical division is adding an ammonia recovery unit at its Pryor, Okla., petrochemicals plant.

The plant, which produces urea from natural gas, has been venting by-product ammonia into the air. About 10 to 15 tons a day of ammonia will be recovered by the new unit. The Refinery Engineering Co. will handle the project, with completion scheduled for late 1958.

JOHN ZINK BURNERS

. . . scientifically tested and performance rated to do the job RIGHT . . .

This research furnace affords an ideal proving ground for design changes in standard lines of burners, as well as enabling the John Zink Company to find *workable* solutions to new problems. In this way the John Zink Company can offer you special burners for your individual application . . . burners that have been *performance tested* before they reach your job site.

The facilities of the John Zink research furnace are available to industry.

WE MAKE HEAT . . . AROUND THE WORLD

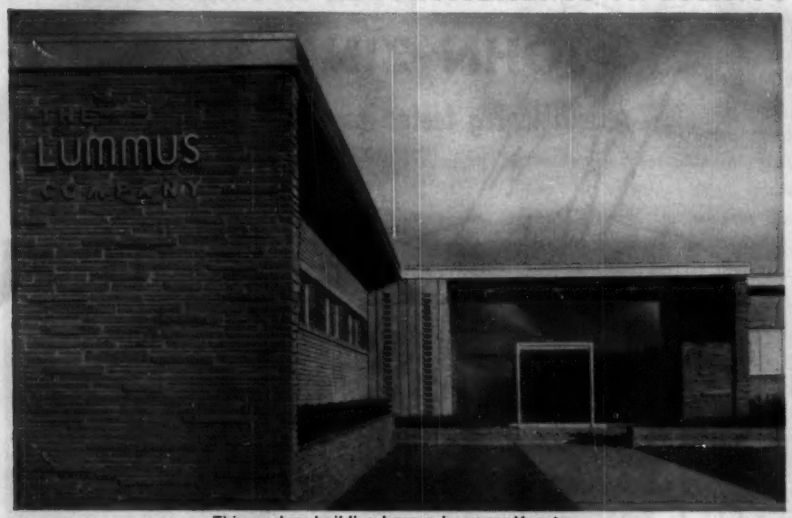
If you have a specialized industrial burner problem . . . JOHN ZINK has the answer . . .

JOHN ZINK COMPANY

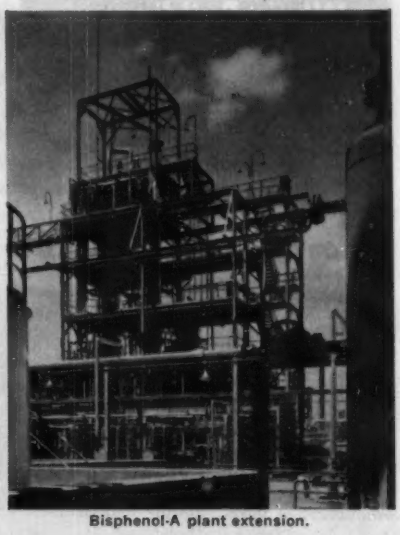
4401 SOUTH PEORIA TULSA 5, OKLAHOMA

For more data on advertised products, use Readers' Service Cards, last page.

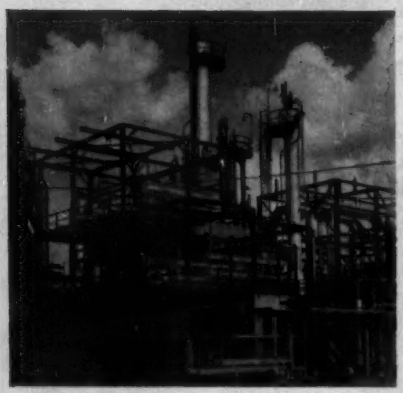
ONE OF A SERIES OF ADVERTISEMENTS ON LUMMUS' WORLD-WIDE FACILITIES



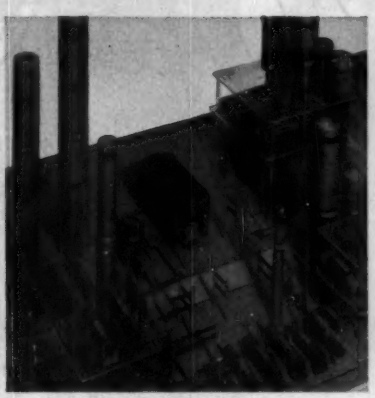
This modern building houses Lummus Houston.



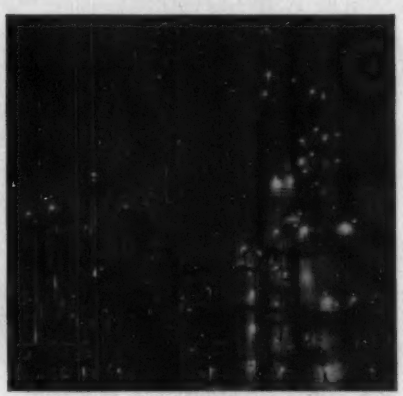
Bisphenol-A plant extension.



First ultraforming unit in the U. S.



$11 million ethylene oxide plant.



Complete refinery.

Lummus Houston serves the Southwest's process industries

Staffed by over 300 specialists—this office is completely integrated for design, engineering and construction for the constantly expanding Southwest

The Lummus Houston office, like all Lummus engineering offices and subsidiaries throughout the world, can design, engineer, procure and construct any size or type plant for the process industries.

Lummus Houston, established in 1939, has to its credit scores of the more than 700 Lummus petroleum, petrochemical, and chemical projects completed throughout the world in the last half century.

Recent Lummus Houston projects, pictured above, include the first Ultraforming Unit in the United States, a Bisphenol-A plant extension with additional facilities for the manufacture of EPON Resins, an $11 million Ethylene Oxide Plant, and a complete refinery which has operated as one of the most profitable in the United States.

The highly trained staff is always ready to join forces with her six sister Lummus offices and subsidiaries—located in New York, Montreal, Maracaibo, London, Paris, The Hague—to make Lummus facilities easily available everywhere.

See Lummus on your next project.

* * *

THE LUMMUS COMPANY, 385 Madison Avenue, New York 17, N. Y., Houston, Chicago, Washington, D. C., Montreal, London, Paris, The Hague, Caracas, Maracaibo. *Engineering Development Center*, Newark, N. J.

LUMMUS

ENGINEERS AND CONSTRUCTORS FOR INDUSTRY

385 MADISON AVENUE, NEW YORK 17, N.Y.

For more data on advertised products, use Readers' Service Cards, last page.

Human Relations Can Be Dangerous

Beware of these three human relations "fantasies" . . . They can cause serious personnel trouble in any company.

Staff Report

"HUMAN RELATIONS" is a relatively new concept which has not fully emerged from the industrial and social situation which has given rise to it.

Upon searching the dictionary and the literature we find it has no clear-cut definition. If we were to depend upon the terms "human" and "relation" to describe it we would be in the position of the college freshman who wrote a term paper on "Indian basketry" by combining a digest of a Book of Knowledge article on "Indian" with another article on "basketry."

Nevertheless, human relations is continually being defined by the process of judicial inclusion and exclusion in the analyzing and solving of specific industrial relation cases and controversies.

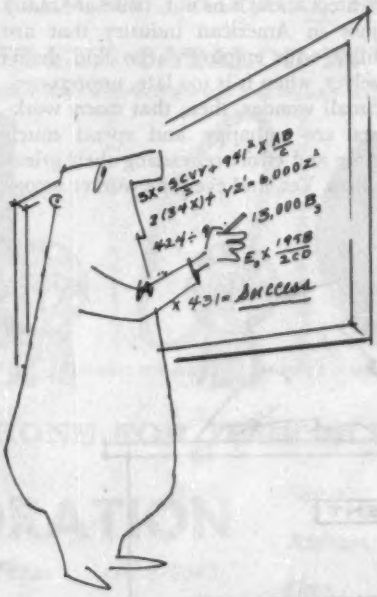
Out of this realistic treatment of concrete cases has developed an understanding of the limitations of human relations principles. It seems, however, that there are many individuals who have not profited by this industrial experience and are still trying to reduce all of the working principles of human relations to one set formula, or one "key," or one "secret."

However, in reducing human relations to a single conclusion, there is the danger of becoming impervious to new findings which do not support it. It saves a great deal of thinking and reasoning to overlook other facts which tend to contradict the conclusion.

These conclusions which are based on some fact, some crystal balling, some wishful thinking, but which cannot be reconciled with the actual happenings in industry today, can be described as "fantasies." And, as such, are dangerous to the supervisor, the executive, and to the worker. These fantasies are responsible, in some measure, for the malady that troubles many personnel departments.

Fantasy #1. *Pick Out a "Key to Success"—and Succeed*—The originators of these well-meant but unrealistic dogmas would get a shock and a practical education if they were little mice sitting under a drafting table or behind a machinist's lathe while the worker read, and commented upon, the unfailing "key to success" that had just been distributed by the supervisor.

The worker's first comment is generally upon the illustrations. The pamphlet asks, "Which way do you want your employe to look?" There sits one worker at his stamping press, singing and smiling, while his machine produces 10,000 ash trays per day. His supervisor has used the unfailing human relations formula on him. Nearby, sits a second press operator. He is unsmiling. He is drooped. He is unhappy. He is not singing. His press is not singing. In fact, it is not even humming. He produces only 8000 ash trays a day. His supervisor has not used the formula on him.



Pick out a "key to success" and succeed.

The sad sack at the second stamping press doesn't worry our worker very much. He looks familiar. Our worker identifies with him. But that smiling, singing, rascal. He's the fake. Our worker hates him. Our worker knows that realistic human relations principles used in the proper doses and at the proper time will increase production and raise morale.

But, it will not make a press operator jump up and click his heels every morning when he is handed his working order for the day that calls for 10,000 small, identical, tin ash trays to sell for 10 cents each.

It is easy to understand why the supervisor, and the worker himself, is constantly seeking some one-shot formula, some technique, or some procedure which will solve the human relations problems. The supervisor wants to spend more time on production and he feels that time spent on solving human relations problems appear to reduce the time he has for his "more important" problem of meeting production goals.

The worker wants to get ahead. He wants more money. He wants to "amount to something." Experience in industry shows, however, that there is no set formula or device that will

"If I believe I can, I can"

cure the supervisor's ills or help the worker reach his aspirations. And most people who look at human relations realistically are quite sure that no such formula can ever be developed.

One fact that prevents the establishment of a set formula, is that change in industry is inevitable. Competition in a democratic country forces each enterprise to change, modify and increase or decrease its facilities. For example, a human relations formula which would work before the days of automation is no longer applicable in many respects.

Another fact is that some formulas, modified to meet changing conditions, can work in certain companies but cannot be automatically applied to all other companies. They must be changed to fit the working situations of each company. One can even go farther and say that some plans can work in some departments of an industry and not in other departments.

Let us take a look at two or three of these one ingredient formulas. While we are looking them over we will consider some facts related to them.

Take for example the cut and dried formula that guarantees promotions and raises if you "prepare" for them. For many a worker it is too late to "prepare." And many times this is no fault of his. His schooling was interrupted by the war. Or other obligations and responsibilities forced him to obtain work, and remain at it, before he could adequately "prepare" himself for future promotions and raises.

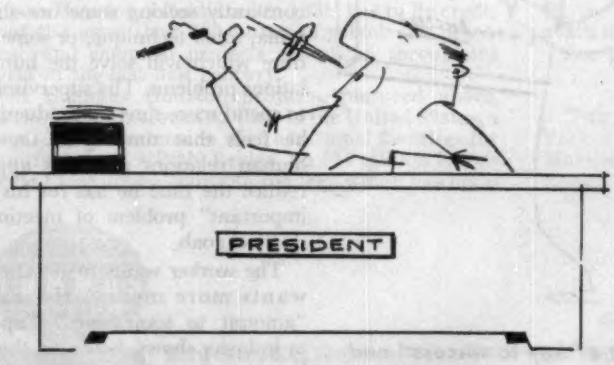
Whether human relations formula writers know it or not, there are many jobs in American industry that are filled with employes who find themselves, when it is too late, unprepared. Small wonder, then, that many workers are unhappy and spend much time and effort rehearsing their grievances. Yet, and even the worker recognizes this, this occupation of self pity is plainly not healthy.

Many critics point a stern finger of reproof at these employes. They do not waste time with details. If these employes are unhappy in their jobs, the critic admonishes, they should get out of them as fast as they can. Or they should stay in and, on principle, keep quite. If they stay in, the critic continues, they must like their jobs, else they are crazy. Because no sane employe would remain long in a job he dislikes.

These critics must be pulling our legs, since the bland assertion of the preposterous is an easily recognized sort of humor. And it is preposterous to think a man is slightly deranged to remain in a job he dislikes. The woods are full of this sort of employe. It is much better to counsel him on ways of finding enjoyment outside his job.

For we must realize, of course, that there is no such thing as a perfect job. Every job has its good points and its bad points. One must be weighed against the other. If the employe feels that he is not getting necessary satisfactions from his daily job, there is something constructive he can do about it.

When the employe sees that he has reached a dead-end as far as promotions and merit raises are concerned and he still yearns for an opportunity to exercise his real talents, it's time for him to look around for an avocation. An off-the-job activity that will give him the pleasure of doing what he thinks he was meant to do. The employe who knows he has some organizational and executive ability, but has no opportunity to use it in his work, can organize community projects and turn in his ability to an excellent purpose.



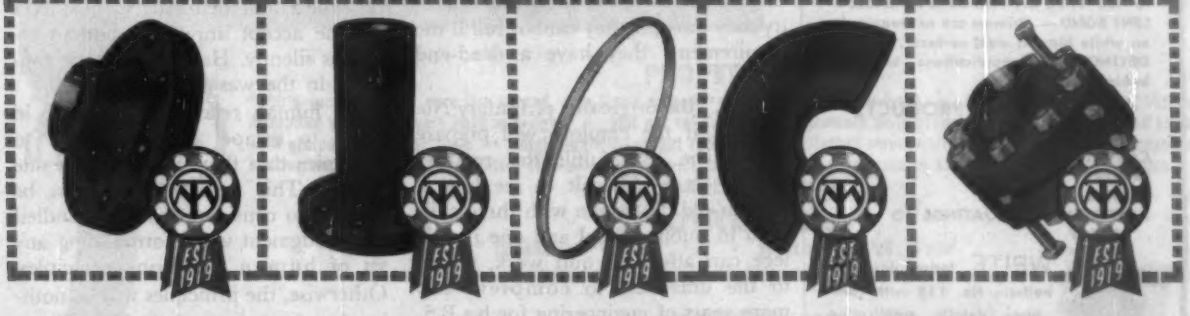
"There is no dead-end job"

Fantasy #2. *"If I Believe I can, I Can"*—Few down to earth, hard working employes are going to swallow the human relations bit stating, "If You Believe You Can Do It, You Can Do It." An employe can believe all day and all night that he can do a certain task, but his abilities, or his intellect, or his training, or his environmental circumstances may keep him from doing it.

One is reminded of the disciple of the Behaviorist School of Psychology who stated, "Give me any child and I will make anything out of him that I care to." A colleague suggested that

Your BLUE RIBBON catalog is now available

THE MOST COMPLETE CATALOG IN THE INDUSTRY



WRITE, WIRE, OR PHONE FOR YOUR BLUE RIBBON CATALOG

OTM CORPORATION

P. O. Box 19296 Houston 24, Texas UN 2-6643

A-1-'58

Name: _____

Address: _____

Firm: _____

Position: _____

For more data on advertised products, use Readers' Service Cards, last page.

WHERE MAXIMUM CORROSION PROTECTION IS REQUIRED

PLASITE®

- For Refining Process immersion service
- For Oil Production equipment
- For Heavy Spills and Fumes
- For Severe Atmospheres
- For Tankers and Tank Cars

PROVEN BY LONG FIELD HISTORY IN

High temperature de-ionized tank lining.
Perco treater lining.
High octane gasoline and jet fuel tank lining.
Cooling towers, hot pipings, fans, and structural steel.
Exterior acid sludge tanks.
Sour crude storage tank lining.
Condenser heads.
Roofs of acid separators.
Concrete tanks, floors, sumps, and bases.
PLASITE Cold Set formulated Coatings from combinations of High Resistant Resins are economical to use.

HEAVY SOLIDS with good coverage . . . HEAVY BUILD 5 to 15 mils per coat without sacrificing film quality . . . MINIMUM NUMBER OF COATS due to heavy build feature, saves labor . . . WIDE CHEMICAL RESISTANCE — all PLASITE formulations have excellent overall chemical and specific superior resistance . . . HIGH TEMPERATURE RESISTANCE from 350° to 400°F. on Dry Film basis . . . EXCELLENT BOND — Primers are not required on white blasted steel surface . . . AIR DRYING Field applications without baking or insulation.

OTHER PLASITE PRODUCTS INCLUDE:
CAULKING COMPOUNDS
PRIMERS
BAKING COATINGS
HEAT RESISTANT COATINGS TO 1200°F.

WRITE today for new bulletin No. 258 with complete details, application information, etc. — without obligation.

WISCONSIN protective coating COMPANY
GREEN BAY, WIS.
REPRESENTED IN PRINCIPAL INDUSTRIAL AREAS

he go to a home for the feeble minded and secure a child with an I.Q. of 50 and make a medical doctor out of him. This, no doubt, induced the disciple to make more realistic statements and to leave the fantasies to others.

For the employe who believes the fantasy, "If I believe I can, I can," there are no limitations. If the problem is to type 120 words a minute all the individual has to do is believe she can and she can. Such fantasy is bad, because it is not true. The abilities of each person are limited. This was so in the past and will remain so in the future. This fact is a part of life and realistic human relations strives to cope with it.

Fantasy #3. *"There Is No Dead-End Job"*—"There is no such thing as a dead-end job, unless it be the top position of the company." A few statistics will prove that statement to be a fantasy. A fourth grade teacher once told a class of 40 students that, "Everyone in this class can be President of the U. S." Not counting the mentally deficient and otherwise handicapped members, we can see that numerically it would be impossible. By the same token, all the employes cannot go up to the top position of a company.

There are other reasons for dead-end jobs, too. In most organizations there are specific requirements that must be filled to advance to bigger and bigger jobs. Some employes just simply cannot fulfill these. And no matter how valuable they are to the company in their present jobs; no matter how hard and conscientiously they work; no matter how much ability they have; if they cannot fulfill the requirements they have a dead-end job.

"But," the originator of fantasy No. 3 says, "if the employe will prepare himself he can fulfill the requirements." It is difficult to see how a 40-year-old draftsman with three children in public school and one in college can afford to quit work, return to the university to complete two more years of engineering for his B.S. degree so he can advance from draftsman to engineer.

And it is very unrealistic to say, "If he had done so and so before he was married . . ." We cannot back up. We must recognize the fact that we cannot neatly set aside this common problem by postulating a cure-it-all solution such as fantasy No. 3.

Many times, for good or bad, an employe is stuck with his job. The thing for us to point out to him is that he can, thank goodness, choose his avocation. This avocation can provide a lasting interest through the years, giving him a constructive, deeply satisfying activity long after it is no longer necessary to have a full time daily job.

Such human relations counseling is more realistic than the "fantasies" passed out daily to the employe. And if we are to use realistic human relations instead of fantasies, we must accept as a realism that good human relations is based on judgment. Formulas and "keys to success" are important as tools and guideposts for action, but judgment is still required to select the proper formula or key to success and to make the proper application of that human relations formula to a specific situation.

The basing of human relations on a set formula without judgment is an over simplification. Such an over simplification is dangerous because the individual who practices it in every situation will find it back-firing on him.

None of this discussion implies that principles and formulas must not be formulated. It does imply that they must be used with discretion. For industry, under the pressure of the influence of competition has made many changes. These changes, particularly those resulting from the general acceptance of changed supervisory methods, have been distinctly in the interest of the individual employe. He no longer accepts unrealistic orders and demands silently. Nor will he accept unrealistic human relations silently. He will toss such fantasies in the waste basket.

All human relations exponents, in order to escape absurdity, have to recognize that there is a negative side to life. This negative side must be taken into consideration and handled with judgment when formulating any set of human relations principles. Otherwise, the principles will be nothing but fantasies and simply will not work in the majority of cases. For the most part, supervisors and employes have a healthy skepticism which leads them to recognize such fantasies and human relations Pollyannism. This is why realistic human relations will not be smothered by the oppressive miasma of fantasies. ##

ABCO ASBESTOLUX

2100 DEGREE TWO-HOUR RATING FIREPROOF BOARD WORKABLE AS WOOD

Asbestolux is a durable, fireproof structural board for structural steel, hazardous refinery conditions, chemical and synthetic plants... where process heat or flammable solutions exist. Ideal for fireproof wall partitions, acid-resistant ducts, fume closets, heat screens, oven linings, floor and ceiling insulation by hot tanks, pipes or chimneys, furnace cladding and linings, switchgear box linings and backing panels for infra-red furnaces, and as structural heat-resistant insulating component for manufactured products.

PROPERTIES:

***100% incombustible, zero fire spread, zero flame spread • will not shatter in heat • durable • excellent thermal insulation value • very light in weight • will not rot • will not promote mold growth • can be nailed and sawed with ordinary carpenter tools • high strength/weight ratio • unaffected structurally and dimensionally by repeated wetting and drying • completely stable—will not swell, twist, warp • immune to attack by vermin and termites • high resistance to chemicals**

SPECIFICATIONS:

Thicknesses: ¼", ⅜", ½" • Sheet sizes: 4'x8', 4'x10'

***Underwriters' Laboratories Inspected and Labeled.**

THE ABER COMPANY, INC.

4832 Almeda Rd. • P. O. Box 2535 • Houston, Texas

Branches:

BATON ROUGE • SHREVEPORT • PORT ARTHUR

For more data on advertised products, use Readers' Service Cards, last page.

As Management Sees It . . .

In negotiating, management must be fair but it must not be bluffed. When an agreement is reached, however, it has to be administered exactly the same to all employes.

What It Takes to Bargain With Labor

H. R. Shepherd
Cities Service Oil Company, Ponca City, Okla.

SUCCESSFUL NEGOTIATIONS of labor contracts require a great deal of skill and tact on the part of the management team. Irrespective of a union committee's attitude, its tactics, or demands it may make, management is dealing with and for its employes, and if possible, should avoid agreeing to anything to the detriment of the majority of its employes. Management must also be fair and honest, yet it cannot afford to be bluffed into giving when it is not justified. You can see, therefore, that management personnel must enter the negotiations confident and well prepared. Here's how they should go about it.

Preliminary Planning. The first step, when a company anticipates contract negotiations, is to arrange a conference with supervisors who actually work with a given contract and who are responsible for its application. Preparatory to this conference, carefully review the contract and make notes of any section or sections that have caused trouble or misunderstandings with employes during the contract year.

At this conference, each supervisor should be asked to explain what he wants and needs to effectively operate under the labor agreement; to make suggestions, and to give reasons why he feels changes are necessary. A thorough discussion should be held on all suggestions, requesting that supervisors express their opinions as to the feasibility of the changes. Management will find supervisors have similar problems and ideas as to what contract changes are needed to correct them.

Study Complaints. Prior to the conference, management should review all complaints occurring under that particular contract since it was last negotiated, and determine whether the complaint was caused by an honest misunderstanding or whether that portion of the contract is ambiguous. In other words, try to determine the cause of the complaint and during negotiations attempt to correct the contract to avoid such complaints in the future, either by changing the wording if necessary or by reaching an understanding with the union as to how that portion of the contract will be applied in the future.

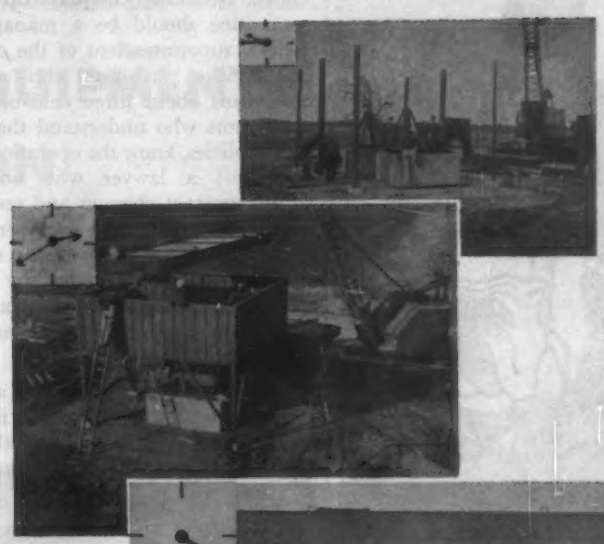
These complaints should be discussed with the supervisors attending the conference, and they should be asked for suggestions for preventing the recurrence of similar complaints. Supervisory personnel are management's most important communications link to classified employes. Their knowledge of employe attitudes and operating problems is indispensable. This type of conference will go far in demonstrating to supervisors that they are a part of management. In addition, it seems to accomplish these other desirable objectives.

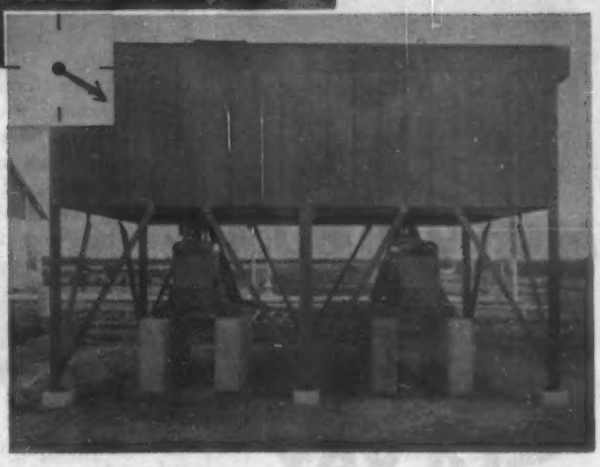
First, it gives supervisors a first-hand knowledge of the problems involved in administering the present contract and also the problems involved in preparing for negotiations.

Second, management benefits by receiving supervisors' opinions as to whether the suggested changes are practical and workable. Management usually obtains excellent reasons as to why changes are necessary, and these reasons can be used to good advantage in negotiating with the union.

Third, supervisors participating in developing a labor agreement know their needs are being considered and their ideas used. Sound judgment suggests they should be consulted.

7 hours 20 minutes





This Smithco process cooling unit was completely installed and ready to operate in less than eight hours.

Through precise planning and engineering skill, time and money saving operations such as this are standard at Smithco. Two major reasons for such speedy installations are: TEST ERECTION — Each unit is completely assembled and disassembled in the plant as a final check before it is approved and released. PREFABRICATION — The units are composed of large easy to handle sections which are completely welded for strength and rigidity.

Test Erection and Prefabrication are just two of the many reasons why the Smithco name is rapidly becoming synonymous with quality products.

It's a Smithco . . . Your Guarantee of Quality

Plant and Offices — Tulsa, Oklahoma
P. O. Box 3217

SMITHCO
Engineering Inc.

For more data on advertised products, use Readers' Service Cards, last page.

For a VARIETY of SIZES

in ALUMINUM CHLORIDE

make yours

SOLVAY

You get a choice of screen sizes to fit your needs – plus uniformity, quality, purity, dependability, service – when you specify SOLVAY Aluminum Chloride.

Write for literature, prices, specific information.

Allied Chemical

SOLVAY PROCESS DIVISION
61 Broadway, New York 6, N.Y.

Branch Sales Offices: Boston • Charlotte • Chicago Cincinnati • Cleveland • Detroit • Houston New Orleans • New York • Philadelphia Pittsburgh • St. Louis • Syracuse

Supervisors are management's first line of contact with employe problems and are directly concerned with any changes in wages, hours, and working conditions in the labor agreement.

The Negotiation Team. The next step is to set up a negotiating committee. Generally, the make-up of the committee should be a manager or general superintendent of the operating division involved who acts as chairman; about three field or plant supervisors who understand the company policies, know the operations and employes; a lawyer who normally drafts contract changes and serves as legal advisor; and a representative from Industrial Relations who should handle negotiations under the direction of the chairman. The make-up of this committee is of paramount importance.

It goes without saying that among other traits, the management negotiator should have the knowledge of Solomon, the patience of Job, and the persuasiveness of Cleopatra.

Soon after the initial conference, the negotiating comittee should carefully screen all proposed changes to determine just how many can be utilized in contract negotiations. After this, another conference is needed with top level supervisors to go over the changes and decide in conjunction with this group exactly what the company is going to shoot for in the way of changes.

Get all Information. The next step is to assemble and analyze all available and pertinent information concerning wages, fringe benefits, hours and working conditions in our industry and related industries. An accurate survey of these items is a must to successfully negotiate a labor agreement.

Another important factor is the complete analysis of the labor agreement, setting out as accurately as possible the cost of its provisions to the company, both actual and potential. The direct cost of labor contract provisions is easily determined, but the potential cost may not be. You must, therefore, consider such things as overtime in excess of wage hour requirements, call-outs, double backs, a specific number of days notice prior to lay-off, severance pay, etc. Such clauses may look harmless, but if conditions are changed, they could cost your company a whale of a lot of money.

As we all know in the oil industry, if the economic provisions of the company's labor agreements are substantially greater than its competitors, both the company and the employes are on very shaky ground.

Last but not least, it is vitally necessary to have the complete support of all levels of management for the program the company is trying to establish in its negotiations. The negotiating committee needs to know before it goes into negotiations just how far management will go on contract changes, wage increases, if any, fringe benefits, and other demands that the union usually makes.

Hear Union Proposals. At the start of negotiations, it is advisable to have the union submit its proposals first. It is good policy to avoid arguments during this period. However, the union officials should be asked to explain in detail just why they need such changes and how the proposed changes will in their opinion affect the labor agreement and company operations. After the complete presentation, adjourn the meeting to study the proposals. When the meeting is re-convened, present the company proposals, following the same procedure. From there on, it is a give-and-take proposition.

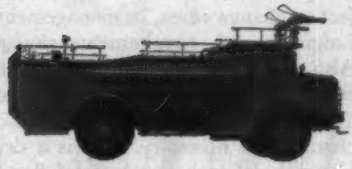
Always try to get tentative agreements from the union on the company's proposals as they discuss each of them.

When discussing union's proposals, try to give logical and sound reasons why you say "No," and take enough time to clearly explain why you take that position. When a definite "Yes" or "No" answer is given, try to be positive and stand on that answer. However, don't take a definite position until you know the entire union program.

Watch Those Proposals. One union demand that should really be watched is the so-called "mutual agreement clause." Usually this type of proposal is an infringement on the prerogatives of management. These clauses provide for a mutual agreement on the number of employes needed to staff a unit, work schedule, expansion or reduction of departmental work forces, etc.

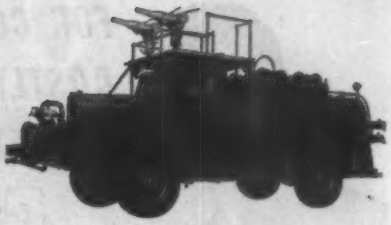
One policy to make clear is a refusal to guarantee to keep any given

For more data on advertised products, use Readers' Service Cards, last page.



WASHINGTON, D. C., NATIONAL AIRPORT

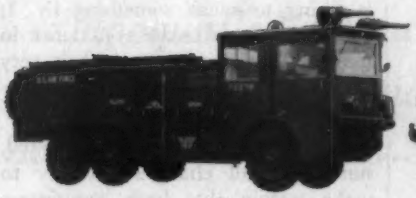
FIRE JEEP — CRUCIBLE STEEL CO. OF AMERICA



U. S. COASTGUARD

ROCKWOOD EQUIPMENT RIDES ON LEADING FIRE TRUCKS

AIRCRAFT CRASH RESCUE TRUCK
FAIRCHILD AIRCRAFT CORP.



U. S. AIR FORCE TYPE 0-11-A

CUBA FIRE DEPT. — NEW YORK

NEW YORK THRUWAY AUTHORITY

THEODORE FRANCIS GREENE AIRPORT
HILLS GROVE R.I.

PORT OF SEATTLE
SEATTLE-TACOMA AIRPORT

GLENN L. MARTIN AIRPORT

The best testimonial of Rockwood's fire equipment is its users. In airports, industries, refineries and municipalities — Rockwood fire fighting equipment is seen on the finest fire trucks.

Fire trucks get the benefit of famous Rockwood nozzles and proportioning systems producing WaterFOG, FogFOAM, FOAM and WET — each designed to conquer different types of fires. By means of Turret Nozzles, these trucks discharge large volumes of FogFOAM, FOAM or WaterFOG. By means of Ground Sweep Nozzles, they fight flowing gasoline fires and protect firefighters and trucks at the same time. By means of Hand Lines, they control fires in hard-to-get-at areas.

If you want precision fire fighting products — by all means send for Rockwood's free booklet. Just fill in and mail the coupon at the right now. Rockwood products have been tested and listed by Underwriters' Laboratories, Inc. Distributors in all principal industrial areas.

ROCKWOOD SPRINKLER COMPANY

Engineers Water . . . to Cut Fire Losses

Distributors in all principal cities

ROCKWOOD

ROCKWOOD SPRINKLER COMPANY
Portable Fire Protection Division
2092 Harlow Street
Worcester 5, Massachusetts

Please send me your illustrated booklet on Rockwood fire fighting products.

Name.....
Title.....
Company.....
Street.....
City.....
Zone.....*State*.....

For more data on advertised products, use Readers' Service Cards, last page.

JOHN CRANE'S line of Chemlon Packing offers an unlimited selection of types, shapes and sizes for practically every service requirement:

..... types best suited for valves and automatic regulators.

..... for high or low-speed centrifugal, rotary or reciprocating pumps.

..... for agitators and mixers.

Here in one bulletin is illustrated and described industry's most complete line of chemically inert packings. You'll save time, trouble and expense on fluid or gas handling problems by requesting Bulletin P-325.

Crane Packing Company, 6420 Oakton Street, Morton Grove, Illinois (Chicago Suburb). *In Canada: Crane Packing Co., Ltd., Hamilton, Ont.*

number of employes on any certain job or jobs; that work requirements are predicated on need and are subject to change when, in management's judgment, job requirements change. Also, that management retains the right to change work schedules when and where, in its opinion, such changes are necessary. This is a definite right of management and should always be protected.

Complete Understanding. In negotiating in the labor agreement, make certain union representatives understand the change and how it affects employes. Always point out the good and bad features of such changes as you understand them. If a change restricts or liberalizes any benefit under the old agreement, reach a definite understanding as to how it will be applied after the new agreement is signed. This procedure minimizes the union's feeling that the company is trying to sneak something by. It usually tends to create confidence in management's honesty, which is very important in successful labor negotiations.

After negotiations are completed, summarize all changes and try to make certain that both committees clearly understand their intent and application. The management committee should compile written notes reflecting the exact intent of all agreements reached during negotiations. Such notes are valuable as reference material.

Making It Work. After the agreement is ratified, then the most important job starts, which is management's communications with supervisory personnel. Most any competent industrial relations man can negotiate a labor agreement, but making the agreement work is the responsibility of all levels of supervisors—from the first line supervisor to the president.

One serious mistake is to negotiate a labor agreement and then just hand it to the supervisors and say, "All right, boys here it is; now live with it." The usual reaction of supervisors is, "Well these guys certainly took care of us. They've got everything in the book, in here, and now our hands are tied so tight we can't even run the place." If these people don't understand why the agreement contains

NEW!

Honeywell Bellows Meter . . .

unequalled for accuracy, stability, versatility in flow and liquid level metering

The new Honeywell Bellows Flow Meter gives the better performance demanded by its potential users. It's the most advanced meter body available today, with important advantages never before found in flow and liquid level meters.

Some of its outstanding features:

Sensitive and accurate—Sensitive to within 0.05% of full scale . . . calibrated accuracy ±0.5% of full scale.

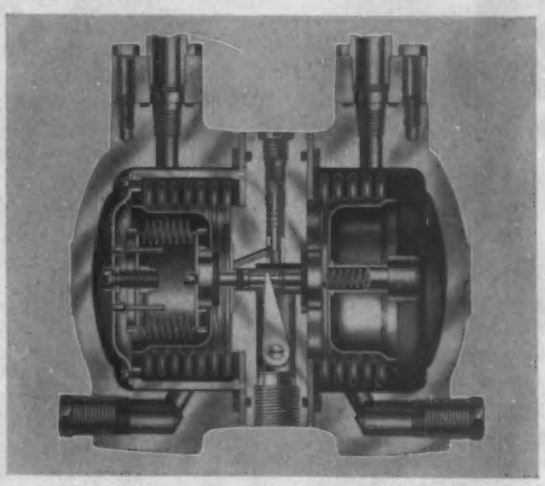
Leakproof—Between liquid fill and process fluid.

Automatically stabilized—Changes in meter body temperature or static pressure have no effect on output shaft position. The Honeywell Bellows Meter operates efficiently in surrounding temperatures of minus 40°F to plus 250°F.

Unmatched convenience features—Including fast range changing in the field . . . connections for both horizontal and vertical piping . . . quick calibration and adjustment . . . easy cleaning and servicing.

High corrosion resistance—Seamless, stainless steel formed bellows give long, trouble-free service with virtually all process fluids.

Fast, effective damping adjustment—New type pulsation check with rectangular orifice enables essentially linear damping adjustment . . . and you can adjust from outside the meter body during operation.



Models are available in many ranges, for both flow and liquid level measurement and control. Get details on *all* the features of the new Honeywell Bellows Meter by calling your nearby Honeywell field engineer today . . . he's as near as your phone.

MINNEAPOLIS-HONEYWELL, Wayne and Windrim Avenues, Philadelphia 44, Pa.

REFERENCE DATA: Catalog C22-1

Honeywell

First in Controls

PRECISION
TEMPERATURE
measurement and control

GORDON
XACTLINE

Controls temperature automatically within a fraction of a degree in any heat process. A complete factory-assembled unit ready for installation anywhere. Can be used with any existing indicating or recording pyrometer controller —regardless of age.

GORDON
XACTEMP
Hand Pyrometer

A quality-built, convenient instrument for quick, accurate temperature reading in molten nonferrous metals. Also, other models of Xactemp for all-around temperature checking.

GORDON
SERV-RITE
Thermocouple Wire
Thermocouple Extension Wire

Insulated in Gordon's own plant to assure consistent quality.
All standard wire and insulations carried in stock for quick delivery. Other wires, in long or short runs, manufactured to specifications.

Full Particulars on Request

5607

GORDON SERVICE

CLAUD S. GORDON CO.
Manufacturers • Engineers • Distributors
Temperature Control Instruments • Thermocouples & Accessories • Industrial Furnaces & Ovens • Metallurgical Testing Machines
615 West 30th Street, Chicago 16, Illinois
2019 Hamilton Avenue, Cleveland 14, Ohio

the changes, they generally feel that the union has really taken the management negotiating committee to the cleaners.

The best procedure to eliminate this problem is that after the new agreement has been in the supervisors' hands for a short period, management should arrange meetings to discuss the new changes and their applications. They should be asked prior to the meeting to review the agreement and make notes of sections that are not clear. When this meeting is finished, all supervisors should have the same understanding as to the agreement's intent and application. Best results can be obtained from these meetings if supervisors are divided into groups of 15 to 25 with mixed levels of supervision.

Uniformity Is Necessary. This type of meeting is especially important in a company which has contracts covering a number of operations in two or three states and several union committees operating under one contract. In these instances, it is mandatory that the agreement be applied uniformly. If management deviates, it is usually charged with discrimination against employes if the deviation is not in their favor. If the applications benefit these employes, the union will contend a precedent has been established and should be extended to all employes covered by the labor agreement.

In administering the agreement, always try to be impartial and fair. Avoid any semblance of considering personalities and be certain that all employes are given the same consideration.

Most companies have learned the hard way not to liberalize or expand the application of any section of their agreements irrespective of how logical the union makes it sound. Make sure employes understand this policy and realize they are going to get just what the contract calls for, no more, no less. By always following this policy and having employes understand it, grievances should be materially reduced. Day-to-day employer-employe problems should always be handled by the complaining employe's immediate supervisor. To do otherwise can easily destroy the effectiveness of supervisors.

Here are a few musts for first line supervisors:

1. Don't Pass the Buck. When an employe request is carefully studied and a "No" answer is called for, don't pass the buck. Be ready to deliver unpopular decisions as well as good news. Help the employe understand the reason for denying his request or suggestion. Most people, if they are aware of all the considerations, will see the reasonableness of "No." Avoid posponement once a sound decision is reached. The employe is waiting for an answer. Tell him.

2. Be Fair But Firm. Establish a reputation for fairness and directness. Men do not respect a supervisor who is wishy-washy. Don't say "No" just to show who's the boss. Employe goodwill and respect grow out of frank and consistent treatment. They are not likely to be won by the supervisor who just says "Yes" to be a good Joe. It may be easier to say "Yes," but such an answer may be difficult to live with and will probably cause considerable trouble in the future.

When a complaint does occur, insist that the complainant first go to his immediate supervisor. The supervisor should take time to discuss it to get all the facts. Then he should tell the complainant that he will study the situation and give an answer after the facts have been reviewed.

If the supervisor is not sure of his position, he should then go through proper lines of communication to management for assistance in establishing a sound and fair position. This position should be relayed back through channels, and the supervisor should give the answer to the complainant. This answer should be final if the facts are correct. This same position should be maintained by management through the various steps of the grievance procedure.

3. Settle Quickly. When a formal grievance occurs, settle it as quickly as possible, through abitration if necessary. The fastest method of settling complaints is too slow, as unsettled complaints cause dissatisfaction among employes. In addition to the morale factor, dragging out of a settlement can cost your company actual money in employe efficiency. Employes spend

For more data on advertised products, use Readers' Service Cards, last page.

For piping systems that can't be anchored, use ZALLEA HINGED EXPANSION JOINTS

Piping systems like the one in this 63,750 bbl/day catalytic cracking unit, one of the world's largest, at Gulf Oil Corp. Girard Point Refinery, have to be entirely self supporting. The entire cracking unit . . . reactor, regenerator and all connecting lines . . . is suspended in a huge structural steel framework, counterweighted to keep the system in balance, and fitted with Zallea Hinged Expansion Joints to provide vital flexibility plus support for the reactor.

In the 150 ft. air supply line, all thermal movement of the piping is absorbed by angular displacement in three 42" dia. Zallea Hinged Expansion Joints. Start-up air in this line is at 1000°F. Under operating conditions it is delivered at 250°F, 25 psig.

Two 50" dia. Zallea Hinged Expansion Joints in the spent catalyst line carry fluidized cracking catalyst at 950°F, 13 psig.

Since this cracking unit first went on stream, these Zallea Expansion Joints have given completely trouble-free service.

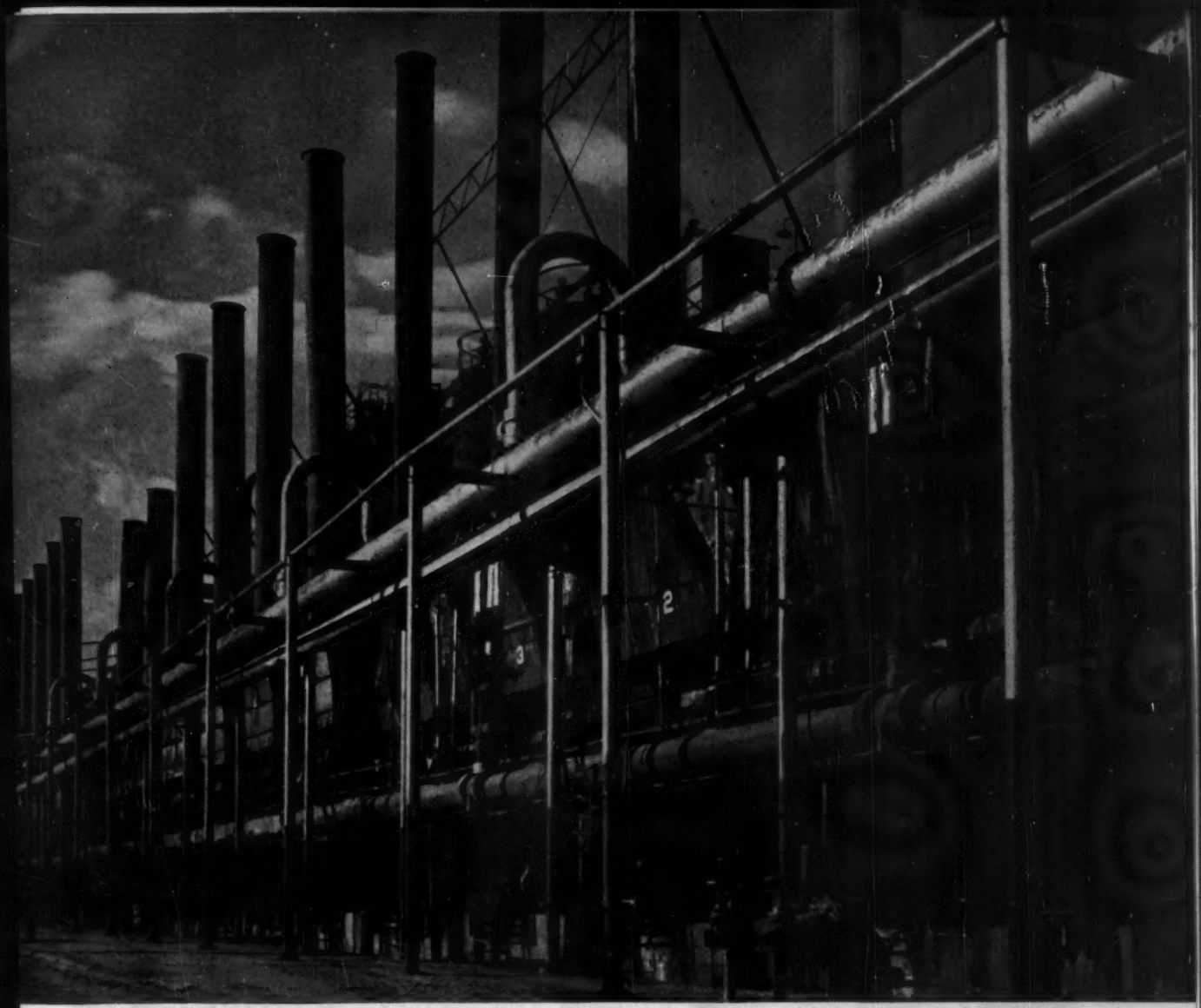
Process piping of any kind can be fully protected with one or more Zallea Expansion Joints. From the complete Zallea line you can select the expansion joint or combination of expansion joints best suited to your particular problems.

Get the complete story in our new 72-page manual. Write today, on your company letterhead, for your copy of Catalog 56. Zallea Brothers, 890 Locust Street, Wilmington 99, Delaware.

Zallea expansion joints

Zallea Brothers • Wilmington 99, Delaware

World's largest manufacturers of expansion joints



Photograph courtesy of Standard Oil Company (N. J.)

When are 16 pipe stills as good as 20?

When a Ljungstrom® Air Preheater gives each one 25% greater capacity

You can get 25% greater production from a pipe still when you install a Ljungstrom® Air Preheater. An Air Preheater can raise combustion air temperature as much as 1,000 F by recovering waste heat from the still exhaust. The increase in combustion air temperature permits an important increase in the output of your still per barrel of fuel consumed.

For example, at one East Coast refinery the installation of a Ljungstrom increased the capacity of a pipe still from 16,000 to 18/20,000 barrels. At this same refinery, the installation of a Ljungstrom, together with modern fuel-burning equipment, gave finer product control which boosted product ratings an average of 2 octane numbers for an added annual income of $58,000.

How fast is "WRITE OFF"?

Users report that increased capacity and improved product quality *alone* pay the cost of the Ljungstrom in as little as nine months. You use 20% less of your regular fuel per barrel of output, or you can switch to cheaper fuels that were previously considered useless. Maintenance is less, too, because a Ljungstrom makes the fuel burn more completely, with minimum slag deposits.

For more complete details on what the Ljungstrom Air Preheater can do for you—for an analysis of the heat recovery benefits attainable in fuel-burning equipment—call or write The Air Preheater Corporation.

Wherever You Burn Fuel, You Need Ljungstrom

The Ljungstrom operates on the continuous regenerative counterflow principle. The heat transfer surfaces in the rotor act as heat accumulators. As the rotor revolves, the heat is transferred from the waste gases to the incoming cold air.

The Air Preheater Corporation 60 East 42nd Street, New York 17, N. Y.

a lot of time during working hours discussing the complaint.

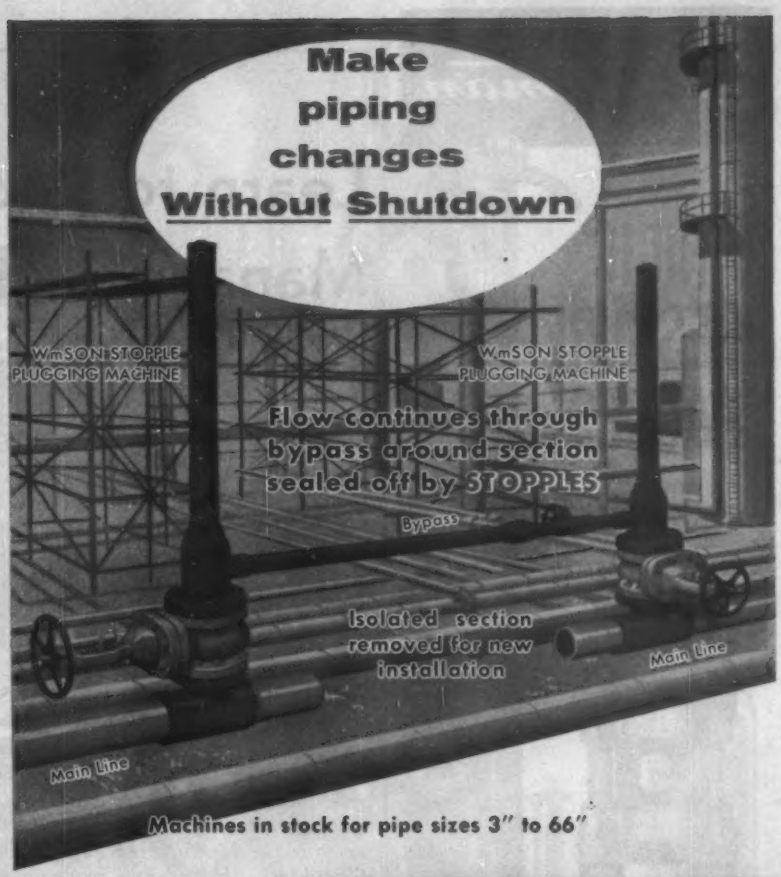
Always remember, that irrespective of a union committee's attitude, its tactics, or demands it may make, management is dealing with and for its employes. Always be honest and above board. Never intentionally ask for or agree to anything to the detriment of the majority of the employes unless it is absolutely necessary. The confidence of employes in their company is of paramount importance. It is something hard to acquire and easy to lose. The company that has it has excellent employer-employe relations, satisfied and efficient workmen, and very little trouble. The ones that don't, generally have the reverse and nothing but trouble.

In dealing with employes, be sure your position is fair and sound. Don't be bluffed into giving when it is not justified, either in negotiating or administering a labor agreement. Treat your employes as you would like to be treated and insist that they give management the same consideration. The old philosophy—Be sure you're right, then go ahead—should be our Golden Rule in handling this important function of management.

Original presentation was before the Natural Gasoline Association of America meeting April 16, 1958, in Dallas.

About the Author

H. R. Shepherd is assistant manager in charge of industrial relations for the Cities Service Oil Co., Ponca City, Okla. From 1933 to 1944 he worked in various phases of refining for Phillips Petroleum Co. He served three years as a representative for the International Union of Operating Engineers in Oklahoma, Kansas and Missouri. He then joined Cities Service Gas Co. as assistant to the president, later becoming director of industrial relations in Delaware. Shepherd has held his present position since 1957.


Make piping changes Without Shutdown
WmSON STOPPLE PLUGGING MACHINE
WmSON STOPPLE PLUGGING MACHINE
Flow continues through bypass around section sealed off by STOPPLES
Bypass
Isolated section removed for new installation
Main Line
Main Line
Machines in stock for pipe sizes 3" to 66"

Large inland Refinery tests 8" Stopple in steam line at 475° F. Held 160 PSI pressure 5 days without leakage.

Machines are for steel or cast iron pipe containing:
• Oil • Gas • Steam
• Gasoline • Water • Propane

Write for article reprints telling how Plants and Pipeline Companies use WmSon STOPPLES and TAPPING MACHINES.

STOPPLES and TAPPING MACHINES may be rented or purchased

T. D. Williamson, Inc.

P. O. BOX 4038 TULSA 9, OKLAHOMA

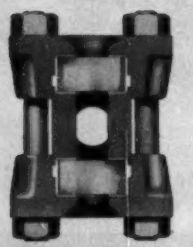
REPRESENTATIVES: HOUSTON • AMARILLO • PITTSBURGH • JOLIET, ILL. JACKSON, MICH. • LOS ANGELES • SAN FRANCISCO • BARTLESVILLE, OKLAHOMA • SEATTLE • SALT LAKE CITY • EDMONTON • TORONTO WINNIPEG • VANCOUVER • BUENOS AIRES • CABIMAS, ZULIA, VENEZUELA • DURBAN, NATAL, S. AFRICA • PARIS, FRANCE • SIDNEY, AUST.

For more data on advertised products, use Readers' Service Cards, last page.

Strahman

HIGH PRESSURE GAUGES

USED IN REFINERIES AND CHEMICAL PLANTS THROUGHOUT THE WORLD



THRU VISION

REFLEX
Single or Multiple Sections

TUBULAR

Gauge Cocks
•
Large Chamber Reflex Gauges
•
Heated or Cooled Gauges

SEND FOR COMPLETE CATALOGUE

STRAHMAN VALVES, Inc.
16 Hudson St., New York 13, U.S.A.

Learn to Recognize and Manage Problem Workers

Persistent drinkers, chronic absentees and several other types of workers have adverse effects on the morale of fellow employes. Here's what you can do about these problem cases.

John J. Thorpe, M.D.,
Esso Standard Oil Company, New York, N. Y.

PERFORMANCE STANDARDS in many refineries today are threatened by a small group of workers which can be classified as "problem personnel."

Some members of this group have recognizable medical or psychiatric difficulties, others have inadequate personalities, many present social problems. They are all problems for the supervisor who must identify members of this minority group and do everything possible to improve their performance.

A good supervisor is constantly on the alert to recognize these problem cases. He can play a big part in understanding and handling them intelligently. Rarely do they yield to a single-handed solution. Most require cooperative effort on the part of the supervisor, his line superiors, and varies staff groups.

Many supervisors need to improve their understanding of these cases and become aware of the help available to them.

A problem employe is one who repeatedly fails to equal a standard of performance established as normal for his fellows. His attitude or behavior usually adversely affects the morale and performance of this entire group.

Successful handling of these problems requires:

- Recognition
- Identification of the cause
- Constructive action
- Avoidance of aggravation

Physically and Mentally Handicapped

In this first group we will discuss two types of individuals. They are:

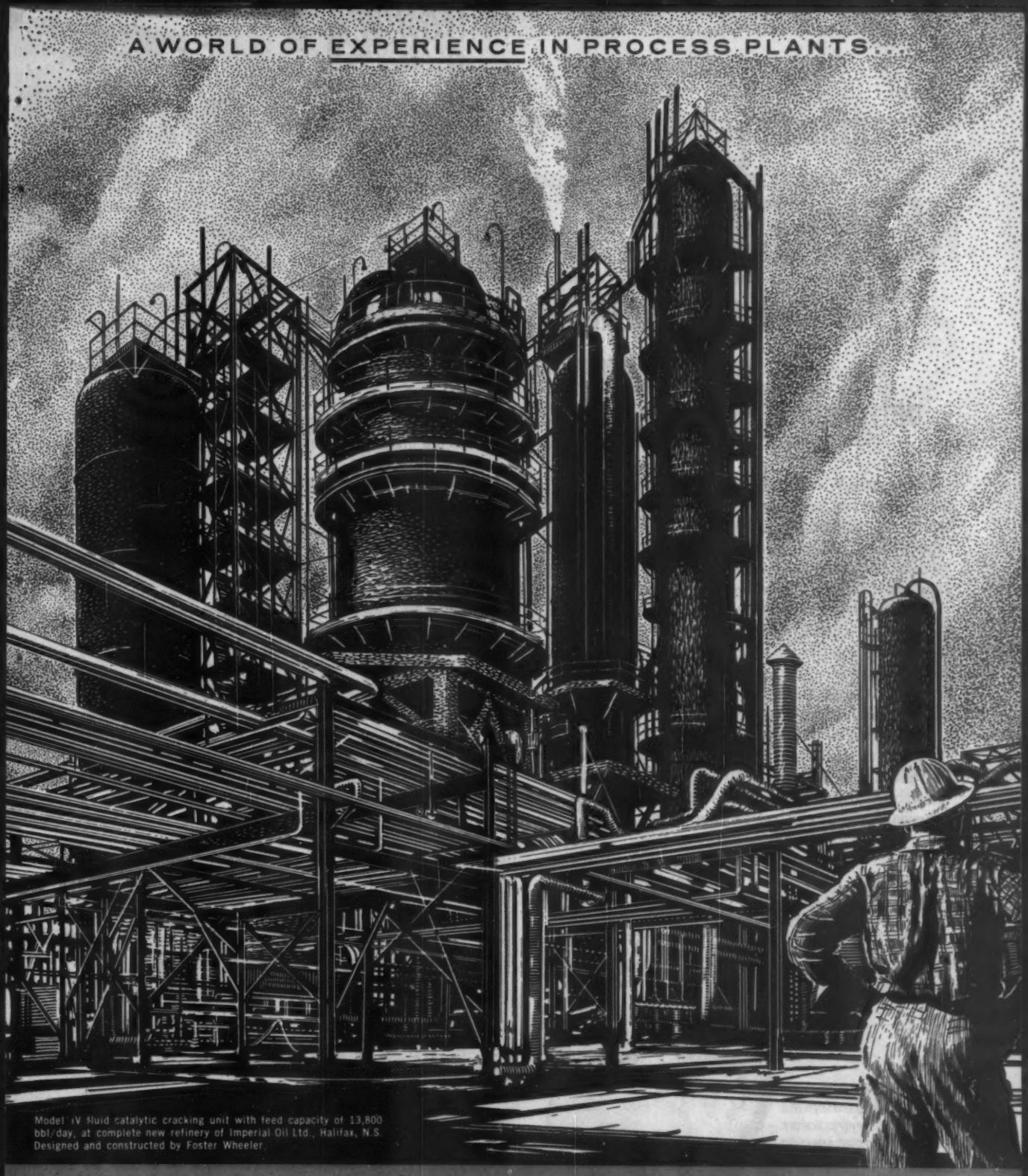
- Partially disabled individuals who are poorly placed
- Employes with below-normal mental capacity

Improperly Placed Individuals with Some Disability. The importance of proper placement of employes with missing limbs, blindness, or paralysis has long been recognized. The need for selective placement in cases of heart disease, arthritis, and other medical disorders is also gaining acceptance. However, there is still an "all or nothing" attitude on the part of some supervisors in cases of this kind.

Knowing this, the man with chest pain on climbing, or back pain on lifting does not try to change job assignment because he fears it may mean "no job." His failure to hold his regular pace, fear and resentment make him a source of poor group morale. He is a problem case.

At the other extreme is the supervisor who takes an overly protective attitude. Accepting a doctor's certificate of "light work" without question or the patient's estimate of what he can and should do on the job, the

A WORLD OF EXPERIENCE IN PROCESS PLANTS...



Model IV fluid catalytic cracking unit with feed capacity of 13,800 bbl/day, at complete new refinery of Imperial Oil Ltd., Halifax, N.S. Designed and constructed by Foster Wheeler.

FOSTER WHEELER *in Canada* ...

Major petroleum and petrochemical plants, completed and on stream, at EDMONTON, MONTREAL, SARNIA, WINNIPEG, PORT CREDIT, HALIFAX.

For new process plant requirements and plant modernization, Foster Wheeler Limited, St. Catharines, Ontario, offers complete design, engineering, fabrication and construction services.

DESIGN
ENGINEERING
CONSTRUCTION

Petroleum Plants
Petrochemical Plants
Chemical Plants

Foster Wheeler Corporation, 666 Fifth Ave., New York 19, N.Y.

NEW YORK • LONDON • PARIS • ST. CATHARINES, ONT. • TOKYO

QUALITY REFRACTORIES

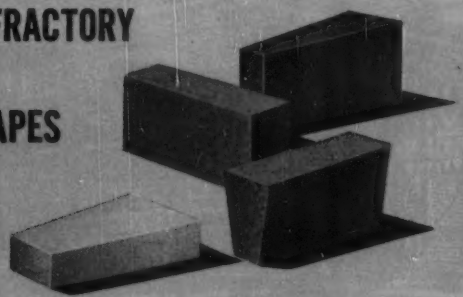
by HARBISON-WALKER serve every petroleum processing need

HARBISON-WALKER products comprise the specific types and classes for each particular purpose. Included are the widely diversified monolithic materials, refractory brick of the entire alumina-silica series and high alumina brands of all classes from 50% to 99+% alumina content. From these can be selected the kinds which best fulfill all the special requirements for maximum corrosion resistance to various sulphur compounds and hydrocarbons and to the severe fluxing effect of oil ash in high temperature furnace operations. Harbison-Walker refractories of the various types and classes are especially adapted for withstanding excessive abrasion and erosion and the disintegrating action of reducing atmospheres through critical temperature ranges.

GUN APPLICATION — For many installations, Harbison-Walker castables are used to best advantage with various types of air placement guns.

TROWELLING—This method is preferred for some applications and the excellent working qualities of Harbison-Walker castables make them easy to use and to secure uniform durable linings.

H-W REFRACTORY BRICK AND SHAPES



Fireclay Brick—All Classes • High Alumina Brick —All Classes from 50% to 99% alumina • DURO and W-ACID, acid-proof brick, floor tile and • DURO tower packing rings and grid tile • Silica Brick • Basic Brick—All Classes

Write Technical Service Department regarding the selection of the refractories best suited for your specific applications.

World's Most Complete Refractories Service

H-W CASTABLE REFRACTORIES and other monoliths

CASTABLES (all classes) · PLASTIC FIRE BRICK (all classes) SPECIAL GUN MIXES · TROWELLING MIXES

These monolith forming refractories are widely used in the petroleum refining and petro-chemical industries. They are available in all the many commercial classes which provide the most desirable combinations of physical and chemical properties for each particular requirement. Among these, several which are most widely used with special benefit in the petroleum industry are briefly described in the following.

HARCAST—Is exceedingly strong and resistant to reducing conditions at operating temperatures and meets rigid specifications used in the petroleum industry. Its composition and low permeability greatly retards corrosion by gases under high pressures. It is used in severe erosion areas such as in regenerator cyclones and catalyst feed lines. The approximate service limit is 2800°F.

H-W 56 LIGHTWEIGHT CASTABLE—Combines light weight with high insulating value and strength to the utmost degree. Produced also with a very low ferric oxide content of less than 0.5%, it provides maximum resistance to reaction with various gases. Among important applications are refinery vessel linings, ducts and breechings, boiler back wall and tube decks, air preheater linings, furnace walls, roofs and doors. The approximate service limit is 2100°F.

H-W EXTRA STRENGTH CASTABLE is exceptionally strong and withstands severe abrasion and erosion at temperatures up to its service limit of 2400°F.

HARCHROME is a special chrome castable which is second to none for abrasion resistance for the range of operating temperatures prevailing in feed lines.

H-W HIGH ALUMINA CASTABLE—Made with crystalline alumina base it is most refractory among castables and due to its extreme purity is especially suited for use in highly reducing atmospheres. Its approximate service limit is 3000°F.

CASTABLE CONSTRUCTION FOR REFINERIES

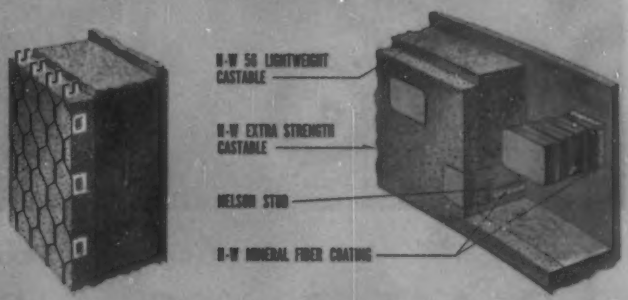


Illustration shows H-W 56 Lightweight (Insulating) Castable next to the regenerator shell with H-W Extra Strength Castable superimposed in hex-steel for working lining.

Typical arrangement of refractory anchor method for monolithic linings in catalytic cracking units. H-W Mineral Fiber Coating provides insulation for metal stud.

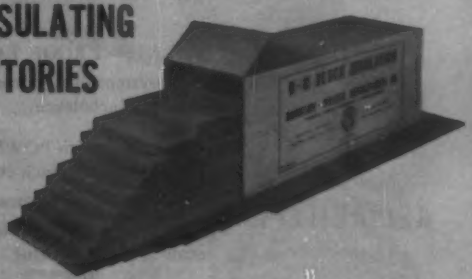
H-W MORTARS

These include a wide variety of both hot and cold-setting cements which fulfill the requirements for laying all the different kinds of refractory brick. Some leading brands are HARWACO BOND, THERMOLITH and KORUNDAL BONDING MORTAR which provide the requirements for laying the alumina-silica and high alumina refractories ranging up to 99% alumina content.

HARWACO MASTIC

This plastic cold-setting monolithic refractory has a working consistency similar to that of stiff putty and is ideally suited for plastering with a trowel, as for example, for sealing V-shaped spaces at the exterior face of tangential tubes.

H-W INSULATING REFRACTORIES



Included are seven classes of insulating fire brick, having service limits of 1600°F. to 3000°F; mortars for laying insulating brick; several brands of castable insulating refractories; H-W BLOCK INSULATION; H-W FINISHING CEMENT; and H-W MINERAL FIBER COATING.

HARBISON-WALKER REFRACTORIES COMPANY AND SUBSIDIARIES

General Offices: Pittsburgh 22, Pennsylvania

Plants, Warehouses and District Sales Offices in many cities and states

employe may wind up in a soft, sheltered spot for months or years. In many instances the employe is performing far below his capacity, knows it, and is unhappy. His fellow employes resent having to "carry" someone forever. Ultimately the supervisor has not one, but a number of problems.

Recognition. Ideally, of course, this problem should be spotted in its earliest stage—when the man first reports to work with a disability or complaint. Any individual alleging physical inability to do his usual job should be referred to the medical department immediately or seen by a part-time company doctor. Restrictions should be spelled out in writing.

A system of periodic review of restrictions at six-month or yearly intervals is mandatory—physical status can improve or deteriorate. Detailed studies of the physical demands of the job plus an equally careful description of physical capacities is often of value, particularly where a large group of people is involved.

The supervisor should always be alert for such cases. Does he have anyone whose performance has slowed down significantly, who appears in pain, or is unduly fatigued or short-winded? Has he kept an individual on shop-work or "the easy job" for several weeks or months just on the employe's statement that he is disabled? If so, the supervisor should refer the employe to the plant physician with a request for medical evaluation.

This does not imply that the doctor has the only word on job assignment. Significant limitation in activity may mean the man cannot do his regular job. Successful placement in another productive assignment will frequently require cooperation of the division or department head or even top management of the plant. In addition, Union agreement may be required if seniority rules or other contract provisions are involved. Finally, the man himself has to want to work, to be willing to try something new, sometimes to take a pay reduction, to insure success.

A lot of effort by a lot of people? Certainly it is. It is well worth it, however, to reduce the hidden costs of ineffective placement.

Employe with Low Mental Capacity. Recognition of such cases is usually no great problem. Basically, these are not "diseased" in the sense of acquiring an ailment after employment. Most of them were recognized when they were employed though they were not considered problems for many years. Childlike in behavior, their mental capacity limits them to simple repetitive tasks. They are usually willing and amiable, but frequently the butt of practical jokers in the plant. As long as their jobs remain the same, they are not considered problems. When some technological or economic change leads to increased job complexity or responsibility they become problem cases.

Although the medical department may confirm the diagnosis by psychological testing, it can contribute little more inasmuch as there is no known remedy. Job rearrangement within a group may occasionally yield a collection of simple tasks which can be done by such individuals. Management alone can decide whether this solution is practicable.

Inadequate Personalities

These individuals usually have no measurable defects like the physically

ONLY the application-engineered

DATAGAGE*

REMOTE MEASUREMENT AND CONTROL SYSTEM

offers these exclusive advantages

NEW ACCURACY
- Only digital system with 1/16" accuracy independent of product gravity.
- Only system satisfactory for use in FLOATING ROOF TANKS.
- Only system to give reliable readings during blending turbulence.

NEW RELIABILITY
- Only system with POWER FLOAT (moving mechanical surface finder) which checks itself automatically.
- Transistors are used instead of short-lived vacuum tubes.
- A true digital system with unlimited-distance, error-safe telemetering.

NEW FLEXIBILITY
- Single dial control for both level and temperature measurement.
- 100 reading point capacity; applicable for alarm devices, valve and pump controls, remote transmission for data processing.
- Application-engineered approach gives you assured performance.

*Trademark registration applied for

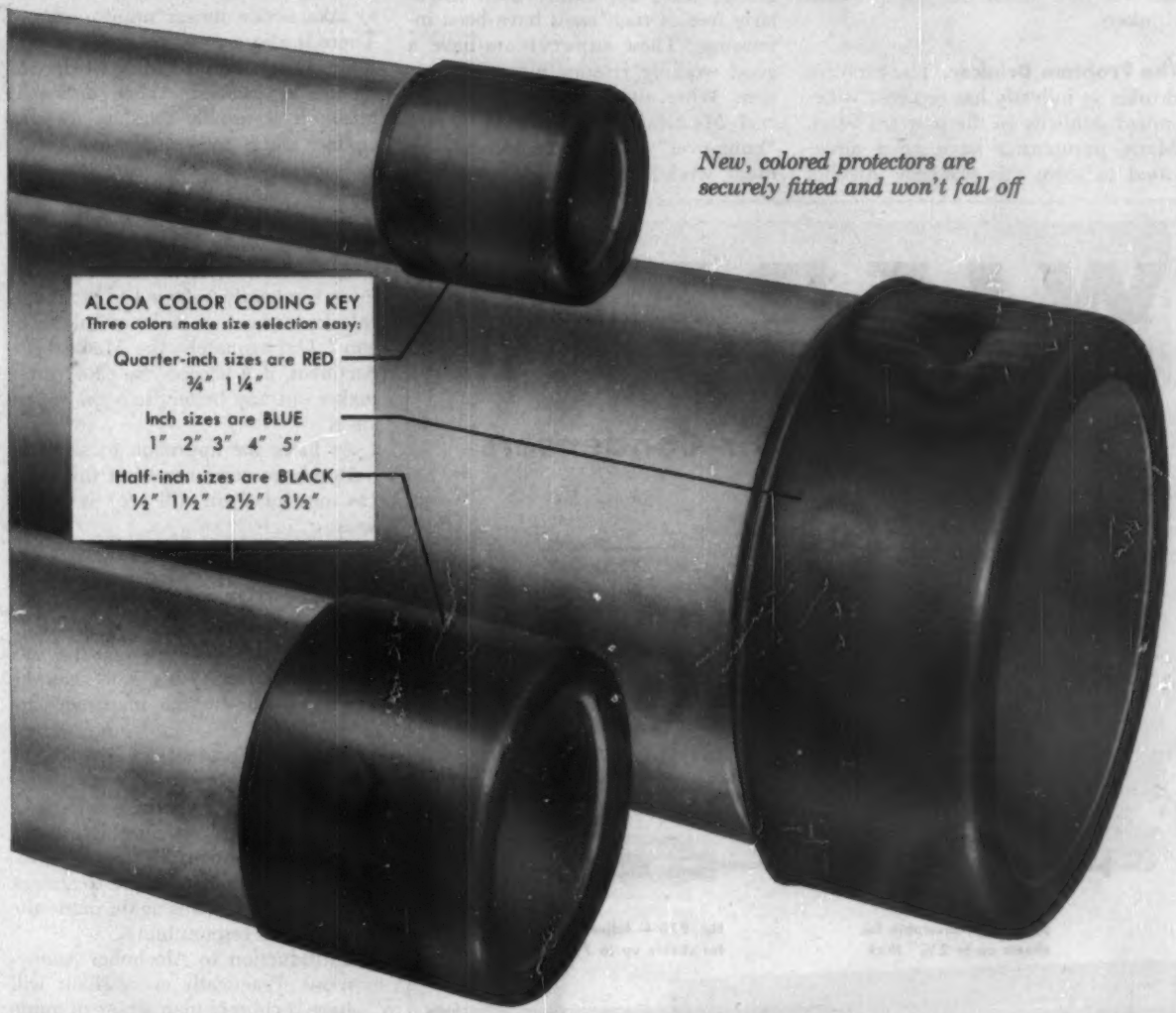
Write for complete information, specify Bulletin M-601.

TEXAS INSTRUMENTS
INCORPORATED
INDUSTRIAL INSTRUMENTATION DIVISION
3609 BUFFALO SPEEDWAY • HOUSTON 6, TEXAS • CABLE: HOULAB

147

For more data on advertised products, use Readers' Service Cards, last page.

NOW! COLOR CODING ON ALCOA RIGID CONDUIT SIMPLIFIES SIZE SELECTION AND STOCKING


ALCOA COLOR CODING KEY
Three colors make size selection easy:
Quarter-inch sizes are RED
¾" 1¼"
Inch sizes are BLUE
1" 2" 3" 4" 5"
Half-inch sizes are BLACK
½" 1½" 2½" 3½"

New, colored protectors are securely fitted and won't fall off

Thread protectors on Alcoa® Aluminum Electrical Rigid Conduit are brightly colored to help you tell size at a glance.

These all-new thread protectors are made to stand up under rough handling in the warehouse or on the job. They spell an end to guesswork and time-consuming mistakes in conduit selection.

With new low prices, Alcoa Aluminum Rigid Conduit is today's most economical buy. Its light weight reduces installation costs. It is nonsparking and nonmagnetic. Excellent corrosion resistance eliminates painting, reduces maintenance and extends life. Find out why Alcoa Aluminum is *your* best conduit buy. Contact your Alcoa Conduit distributor or write Aluminum Company of America, 2325-E Alcoa Building, Pittsburgh 19, Pa.

ALCOA ALUMINUM CONDUIT
ALUMINUM COMPANY OF AMERICA

Underwriters' Laboratories, Inc. INSPECTED
RIGID CONDUIT
ISSUE MU-28

Your Guide to the Best in Aluminum Value

"ALCOA THEATRE"
Exciting Adventure
ALTERNATE MONDAY EVENINGS

For more data on advertised products, use Readers' Service Cards, last page.

or mentally handicapped, and undergo no periodic changes in thought or feeling that fit an emotional illness. Their environment does not differ radically from their fellows but their reaction to it is consistently peculiar. The only persons in this group we will talk about are the problem drinkers.

The Problem Drinker. The problem drinker in industry has received widespread publicity in the past ten years. Many programs have been advocated to solve this problem. Alcohol becomes a problem when its use or immediate after effects impairs job performance or attendance. The supervisor should be the one to decide when job performance is below normal because of alcohol.

Discussions with supervisors whose groups have apparently been singularly free of such cases have been interesting. These supervisors have a good working relationship with their men. When an employe turns up several Monday mornings in a row "hung-over" and unable to carry his usual work-load, the supervisor tells him he is aware of the part alcohol plays in the situation, and that he expects improvement. Appreciable success is claimed for this method.

Delay Is Costly. Many supervisors delay too long before taking this step. They ignore the early signs because to take notice means unpleasantness. There is also a great tendency to find reasons why the individual's behavior should be excused. When action is taken, it is usually too late for discipline alone to be effective. Here another mistake is often made. The problem continues at a minor disciplinary level despite repeated lapses. Ultimately a "last chance" is thrown away and the man is discharged or, more frequently, referred to the medical department as a "medical problem." Unfortunately, the Medical department, if it accepts the case, rarely makes out any better than the supervisor.

At Esso, the approach to an alcohol problem encountered at this stage (as most of them still are) is as follows:

1. Complete medical evaluation by the doctor to determine whether there are physical evidences of disability caused by alcohol—e.g., cirrhosis of the liver, neuritis, etc. Treatment for this can then be carried out by the man's private physician.
2. In many instances referral to a psychiatrist is advisable to determine if the drinking is merely a symptom of a recognizable psychosis or psychoneurosis (in most instances it is not). Where treatment is indicated, this is again made the employe's responsibility.
3. Introduction to Alcoholics Anonymous. Practically every plant will have a contact man who can guide the problem drinker to a group with whom he will feel comfortable Intramural or company sponsored groups are relatively ineffective because they tend to lose their "anonymity."

Where there is no clearcut medical or psychiatric problem under treatment, management should indicate to the employe that he is on probation. Further alcohol lapses will be cause for disciplinary action.

We do not agree that alcoholism is a disease in the usual sense. Although it is true that advanced forms show compulsive features toward drinking or continuing to drink, most retain

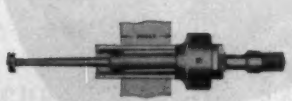
WIEDEKE

THE QUALITY NAME IN TUBE EXPANDERS . . . SINCE 1892

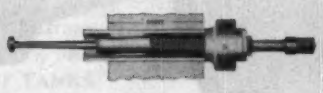
Tube Expanders for Condensers

No. 255—for average tube sheets

No. 270—for thick or multiple tube sheets



No. 255—Adjustable for sheets up to 2¼" thick



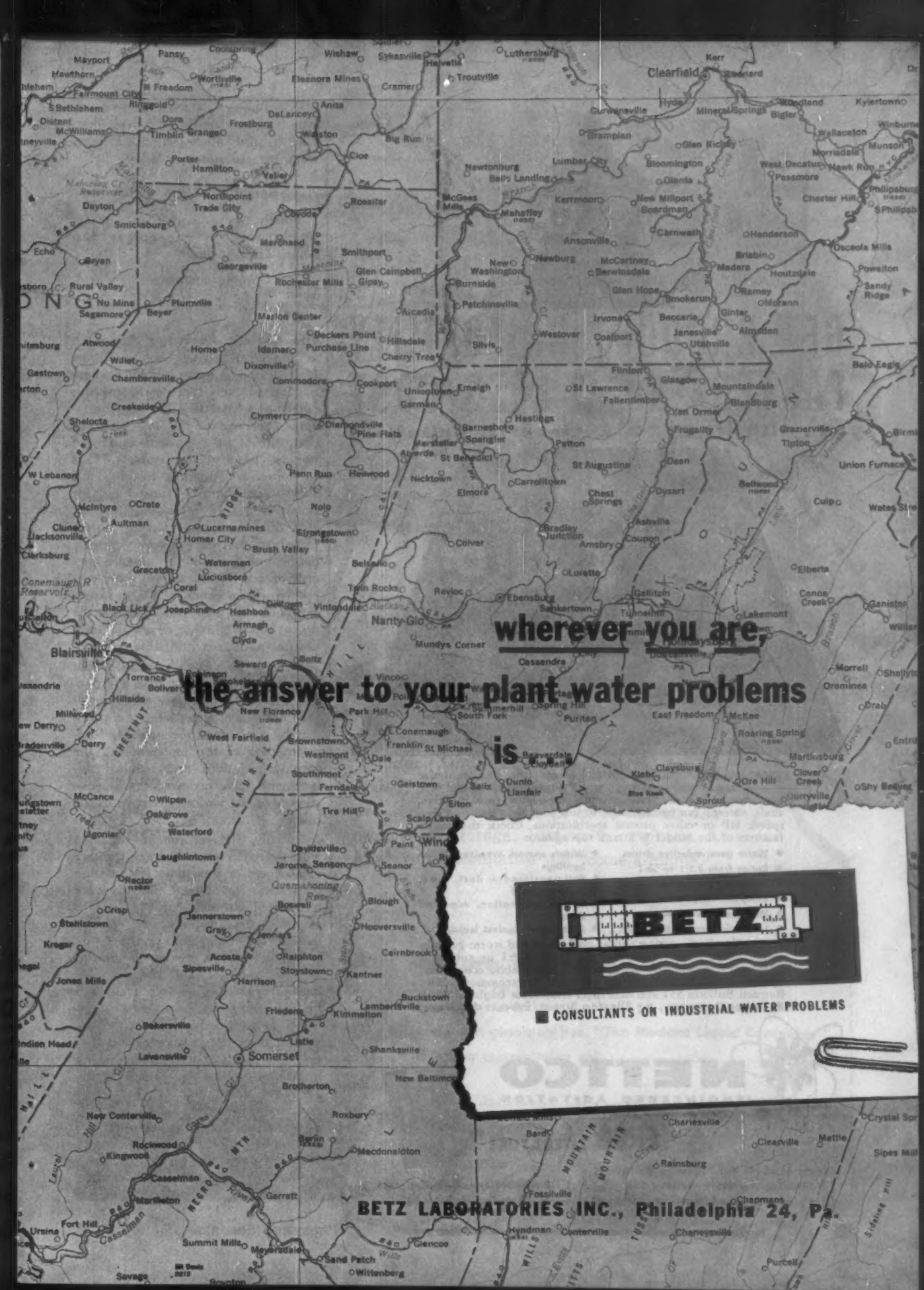
No. 270—Adjustable for sheets up to 7½"

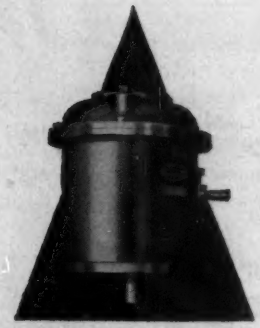
#36

IDEAL Ball Bearing Tube Expanders are made of special analysis alloy tool steels, carefully heat-treated to withstand the severest operating strains. They are adaptable for use with any torque controlled tube rolling units—air, electric or mechanical. *Confidence* is your assurance that your job will be done *RIGHT* . . . when you use WIEDEKE Specialized Tube Expanders, Tube Cutters and Operating Accessories. There is a Wiedeke Distributor in every principal city. For further information write for *new* General Catalog 81.

The Gustav WIEDEKE Company

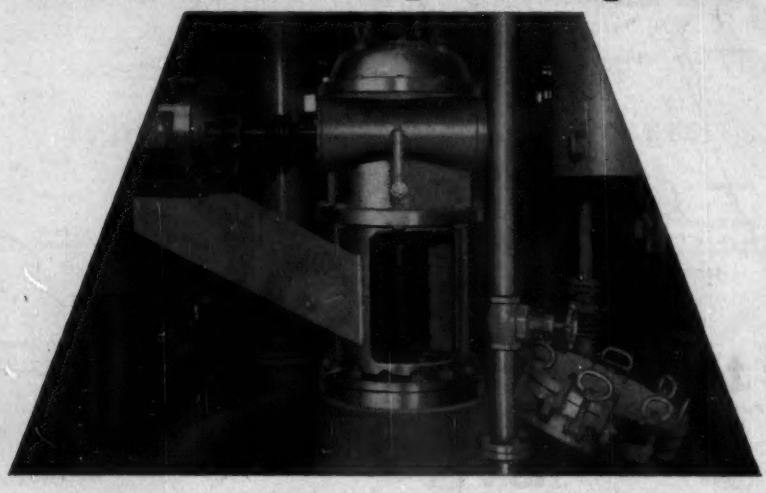
Dayton 1, Ohio


wherever you are,
the answer to your plant water problems
is
BETZ
CONSULTANTS ON INDUSTRIAL WATER PROBLEMS
BETZ LABORATORIES INC., Philadelphia 24, Pa.



GET PRODUCT UNIFORMITY FASTER and at LESS COST

. . . with NETTCO Engineered Agitation!



INCREASE PRODUCTIVITY, lower power costs, and minimize maintenance requirements . . . with "process-rated" Model WT agitators by Nettco. Standardized components (motor, drive, shaft, stirrer) can be combined to suit your most exacting size, speed, HP or other process specifications. Check the design features of the Model WT tank top agitator . . .

- Worm gear reduction drives
- Ratios from 3.5:1 to 68:1
- Seven sizes available
- Complete range of speeds
- Minimum moving parts
- Large diameter vertical shaft
- Widely spaced, oversized Timken bearings
- Fully enclosed — dust, fume, moisture-proof
- Splash lubrication, drip-proof design
- Oil-trapped against leakage

Model T units, featuring helical gear trains and worm gears in combination, offer ratios from 6.25:1 to 100:1 in numerous "process-rated" models designed for dependable, economical operation. Ask Nettco agitation engineers for recommendations. Request Bulletin 551 and data sheet from New England Tank & Tower Company, 81 Tileston Street, Everett 49, Mass.

NETTCO

ENGINEERED AGITATION

FREE LITERATURE

Please send me the following literature:

☐ Tank Top Agitators—Bulletin 551
☐ Portable & Tripod Mixers—Spec. Sheets
☐ Pipeline-Flomix®—Bulletin 531
☐ Side Entering—Bulletin 532

freedom to seek nelp but fail to do so. The "disease concept" removes whatever helpful effect the idea of personal responsibility can have.

Social Problem Cases

Finally, there are employes whose problems are primarily social in character. These include:

- Chronic absentees
- Accident prone employes

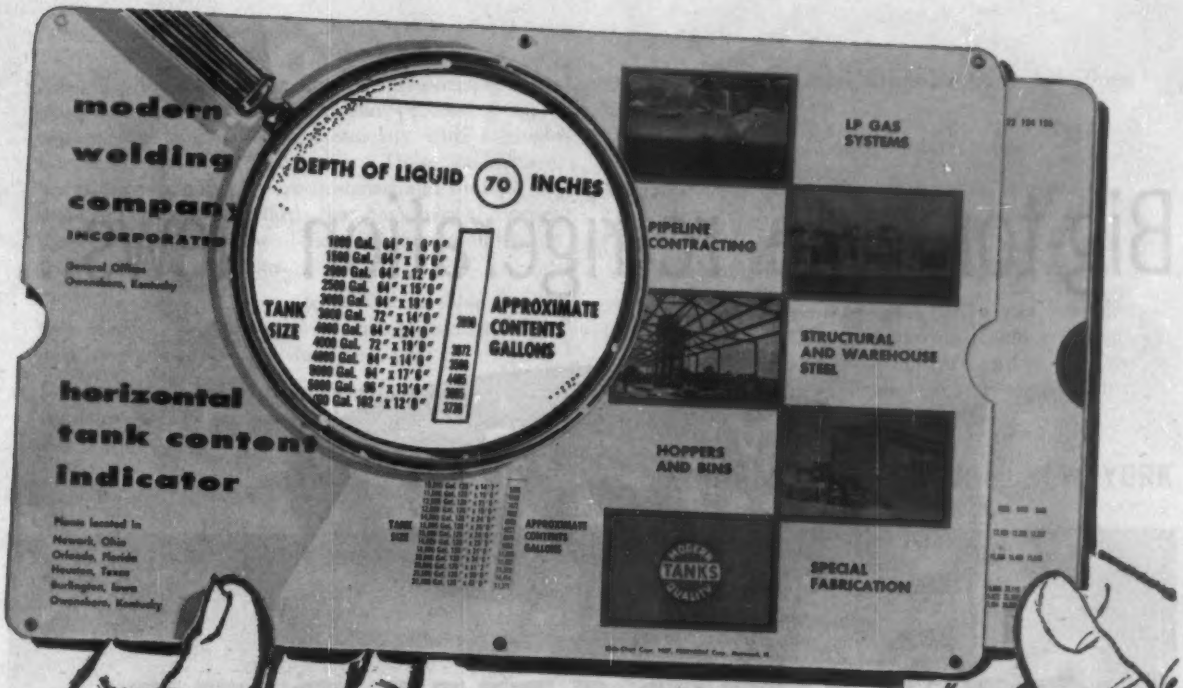
The Chronic Absentee. Inasmuch as the most obvious excuse offered for repeated absences is sickness, there has been a tendency to regard this person as a Medical department problem. The error of this reasoning has been shown by consistent failure of isolated Medical department efforts to control the situation. In any single short-term absence caused by, for example, a cold or intestinal upset, it is often impossible for the doctor to be sure that the employe was truly disabled. Review of the absence record for a period of several years correlated with a complete health inventory, however, will usually enable the doctor to say whether or not the total absence pattern is justifiable.

What is done at this point depends on management rather than the doctor. Over the past few years many Esso units have approached the problem by the committee method. Representatives of top management, the employe relations and medical departments have reviewed the absence records of the various divisions in the plant.

Initially, the records of employes who exceeded an arbirtrary number of absences or total days lost because of sickness for at least two years are scrutinized carefully. In one plant, for example, the arbitrary level used is five absences or 25 days per year.

The committee reviews the record with the division head and the first-line supervisor. The doctor confines his remarks to non-confidential statements as to whether or not the absence pattern has valid medical reasons. If a medical condition exists, he further notes whether or not appropriate treatment has been sought by the employe. Where a chronic medical condition exists he also estimates the probability of rehabilitation or whether medical retirement is in order. The supervisor discusses the employe's attitude and performance

For more data on advertised products, use Readers' Service Cards, last page.



Yes, efficient storage is our business:

And efficient storage includes accurate inventories. To help you with these records, a new **"Modern Liquid Computor"** is available *absolutely free.* There are many other ways **Modern** can help you plan for more efficient and economical storage. Just write or phone. A **Modern** representative will "come a-runnin'".

MODERN TANKS QUALITY

modern welding co.
INCORPORATED
1500 EAST 12th STREET
OWENSBORO, KENTUCKY

BURLINGTON, IOWA
HOUSTON, TEXAS
NEWARK, OHIO
ORLANDO, FLORIDA

Modern Welding Company, Inc.
1500 East 12th Street
Owensboro, Kentucky

Please mail, absolutely free, **"The Modern Liquid Computor".**

Have your representative call: _____
(Date)

NAME: _____

COMPANY NAME: _____

ADDRESS: STREET _____ CITY _____

For more data on advertised products, use Readers' Service Cards, last page.

Big-tonnage refrigeration news...

Carrier

CENTRIFUGAL COMPRESSORS

with broad application flexibility
now in increased capacities up to

3000 tons

Now, the big-tonnage refrigeration requirements for many large chemical and petroleum processing applications can be handled economically with a single Carrier Centrifugal Compressor. These multi-stage, heavy-duty centrifugals are designed and built to the same high-quality standards that have earned Carrier the reputation for around-the-clock dependability on thousands of applications.

With unit capacities up to 3000 tons, these Carrier Centrifugal Compressors provide many installation and operating advantages. To mention a few:

Extreme flexibility of arrangement with coolers and condensers. Four of many combinations are illustrated.

High lift or wide temperature range in two, three or four stages.

Side loading for split load requirements.

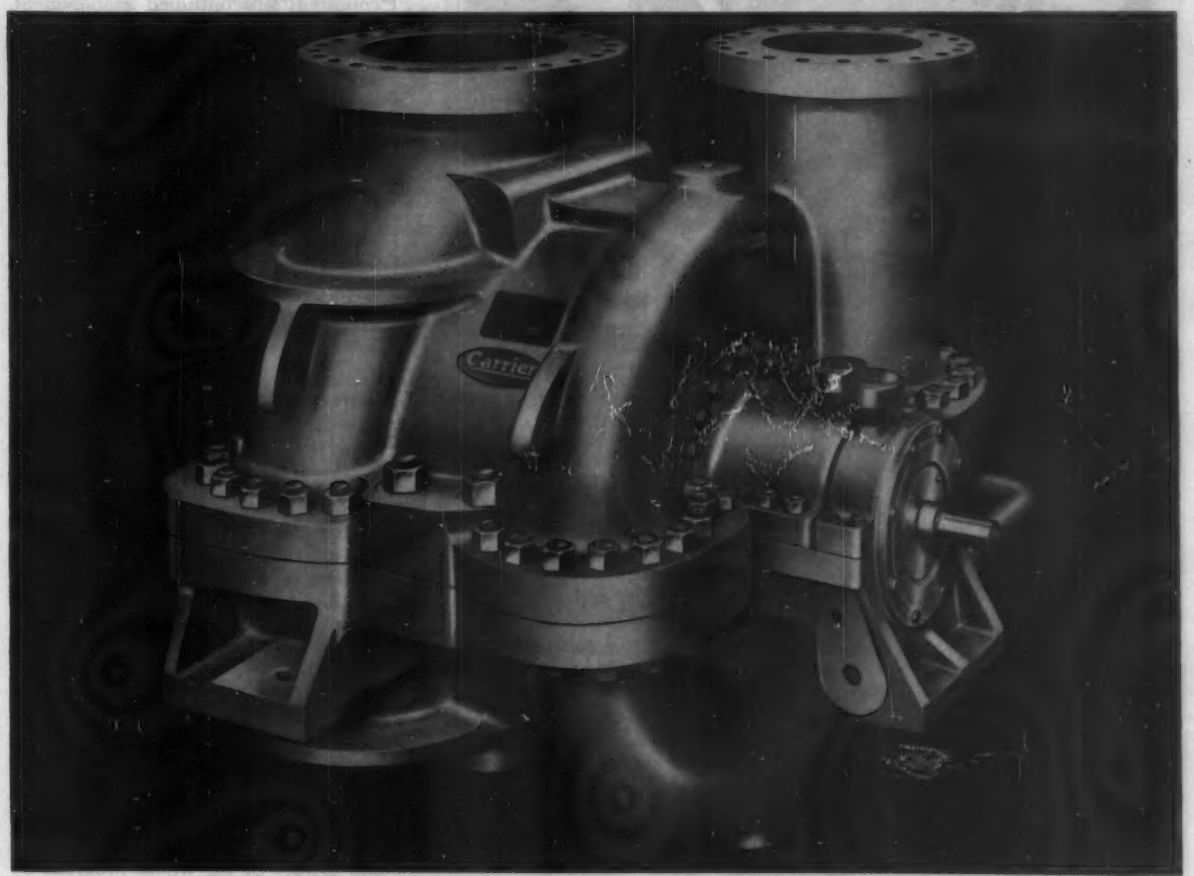
Variable inlet guide vanes for capacity control.

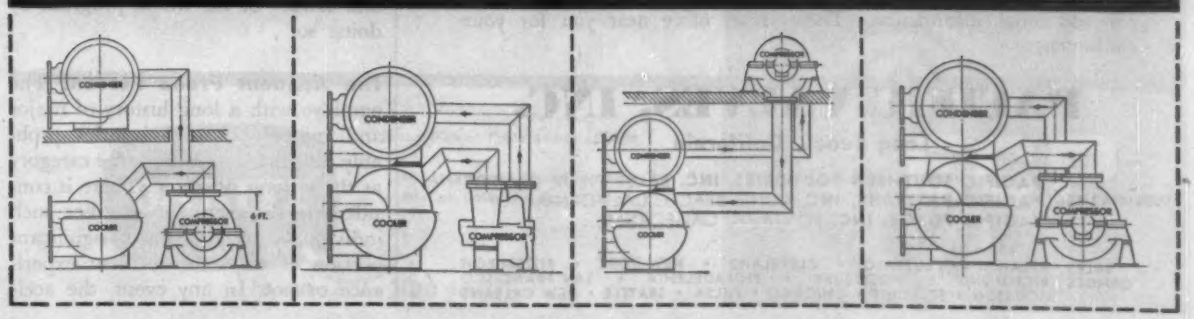
Suitable for all types of drives.

Versatile use with any high-pressure refrigerant.

Whatever your requirements, the Carrier specialist in your area can make an impartial recommendation. For information about these big-tonnage Carrier Centrifugals and specific application to your requirements, call your nearest Carrier office, or write

CARRIER CORPORATION, SYRACUSE, NEW YORK





For more data on advertised products, use Readers' Service Cards, last page.

FULL PRODUCTIVITY demands *

Proper design, proper material of construction and uncompromising attention to absolute machining practices are fundamental of good quality and dependability. Dependability is an ally of maximum operational productivity. PACIFIC can give you promise of meeting and maintaining those expected production quotas with valves of shock absorbing toughness, designed for performance and the lasting service you desire.

Proper design of PACIFIC valves includes full open ports with straight thru flow for greater efficiency; close fitting, integrally machined guides in body and wedge for unlimited ease of operation; integrally forged T-Head and stem connection for greater strength and stability; male and female bonnet joints for safety and alignment; deep stuffing box of ample depth to accommodate lantern ring and sufficient packing for an effective seal; lubricated acid resisting yoke sleeve for smoother operation. These and other refinements incorporated in PACIFIC'S valves is your greatest assurance of minimum maintenance and trouble-free operation. And these features are available to you in a complete line of cast steel and stainless steel valves to fit your every service requirement. Whatever your specified service need, you may be sure PACIFIC'S availability of an unusually wide selection of materials and facilities will meet your specifications for quality and delivery dates. Find out more about PACIFIC . . . why it can mean greater profits to you, right now. Write or call PACIFIC for additional information. There is an office near you for your convenience.

PACIFIC VALVES, INC.

Long Beach, California

SUBSIDIARIES: **PACIFIC SOUTHERN FOUNDRIES, INC.** BAKERSFIELD, CALIFORNIA
PACIFIC PATTERNS, INC. LONG BEACH, CALIFORNIA
PACIFIC FORGE, INC. FONTANA, CALIFORNIA

SALES OFFICES: ATLANTA • BUFFALO • CLEVELAND • NEW YORK • PITTSBURGH
RICHMOND • WOODBURY • PHILADELPHIA • SAN FRANCISCO
HOUSTON • ST. LOUIS • CHICAGO • TULSA • SEATTLE • NEW ORLEANS

on the job, the attitudes of his fellows, etc.

Non-Medical Conditions. Frequently, non-medical factors come to light during the discussion which are of primary or secondary importance. The employe may have another part-time job or small business that competes for his time. He may have a complex maritial or financial situation or be unusually interested in sports or other recreation resulting in periods of fatigue.

Where no clearcut medical reason for the absence pattern is apparent, the supervisor discusses the situation with the employe emphasizing that regular attendance is an important condition of continued employment. This is supplemented by a management letter emphasizing these points and indicating improvement is expected.

Follow-up reviews of cases are conducted by the committee at intervals of six months to insure that improvement occurs and is maintained. Results of this program have been extremely satisfying. Salutary effects are often observed among fellow workers as well as in the particular employe studied in this manner.

Supervisor Must Know. Basically this program depends on the supervisor for success. He must know his men and keep a constant check on their attendance pattern. Time off for personal reasons should be checked as carefully as the sickness absence pattern. Though it is not the supervisors right to inquire into the confidential aspects of sickness or personal absence, the employe should be made thoroughly aware of the supervisor's interest in his attendance.

At times, the supervisor may become overenthusiastic in his approach and make his own interpretation about a given sickness absence. He risks justifiable employe resentment and failure of his whole program by doing so.

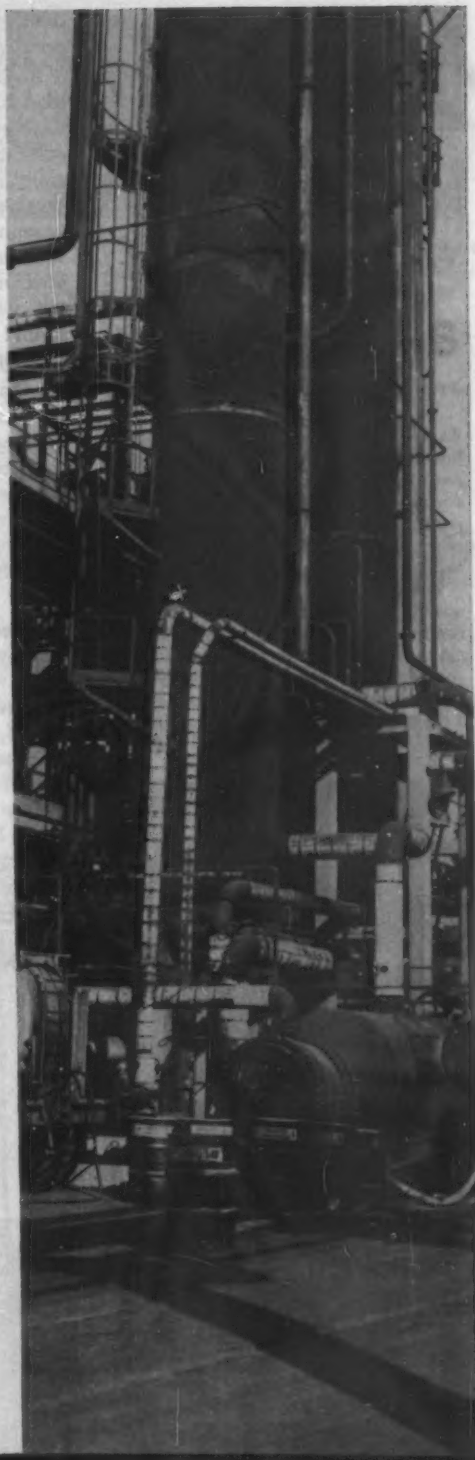
The Accident Prone Person. The employe with a long history of major and minor industrial injuries probably falls into much the same category as the chronic absentee. There is considerable disagreement whether such individuals account for a significant portion of the total accident experience or not. In any event, the acci-

For more data on advertised products, use Readers' Service Cards, last page.

Oakite ECP

engineered cleaning program

cuts turnaround to 32 hours, saves 75% in costs



Its ⅛" tray perforations nearly choked with scale, a 40-foot, 12 tray absorber tower needed thorough cleaning in the worst way. The trouble was time. The last cleaning, by hand, had taken 5 days and $3000.

Refinery engineers called in the Oakite man for an ECP. For this particular job he prescribed an Oakite solvent-acidic type cleaner—one that would remove not only caked-on carbon but sulphur and iron oxides as well. Results: tower cleaned in 32 hours at a cost of $750. Savings in turnaround time—3½ days! Savings in cost—$2,250.

WHAT IS OAKITE ECP? ECP stands for *Engineered Cleaning Program.* It's a program of chemical cleaning developed for your refinery, your equipment, your conditions, your throughput. It itemizes the problems, and the methods and materials to solve them. It puts the chemistry of cleaning to work for your benefit. It's supervised by a refinery-experienced Oakite engineer. Before you plan your next turnaround, call the Oakite office nearest you, or send for Bulletin F10102. Oakite Products, Inc., 50B Rector Street, New York 6, N.Y.

SPECIALIZED INDUSTRIAL CLEANING
OAKITE
MATERIALS · METHODS · SERVICE
SCIENCE

In our 50th year.

Export Division Cable Address: Oakite

Technical Service Representatives in Principal Cities of U. S. and Canada

Oakite ECP
your economy key

For more data on advertised products, use Readers' Service Cards, last page.

dent repeater still poses an individual problem.

So-called accident prone persons may have certain personality features —aggressive, impulsive, unable to tolerate authority, and maladjusted socially are descriptive terms that have been applied. Though experimental attempts have been made at handling such cases by psychological or psychiatric methods, it is still too early to tell whether these will have widespread practical value.

Studies have indicated that accident proneness may be a temporary state encountered in the younger employe group with distracting personal or home problems. Here again the good supervisor may spot a potential accident repeater. Counselling and judicious job assignment may well avert further trouble.

Summary. A small percentage of employes in modern industry fails to meet the standards of performance established as normal for the majority. Maintenance of optimal productivity and high group morale demands that the supervisor be constantly on the alert to recognize these problem cases. He can play a big part in understanding and handling them intelligently.

This is an abridged version of a paper presented at 22nd Midyear Meeting of the API Division of Refining, May 14, 1957, under the title of "The Recognition and Management of Problem Cases in Refinery Personnel."

About the Author

Dr. John J. Thorpe is associate medical director for Esso Standard Oil Company at New York. He is responsible for coordinating medical services in various Esso refineries and clinical services in the headquarters office. Dr. Thorpe received his M.D. degree from Cornell University. He was a physician for Standard Oil Co. (N. J.) from 1949 to 1952 and assistant medical director for Esso from 1952 to 1957.

PUMP CLINIC

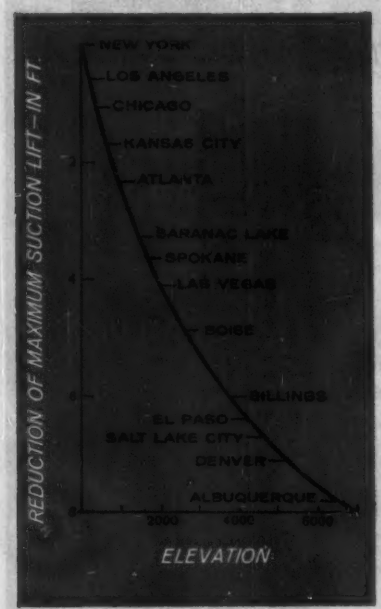
altitude:

ITS EFFECT ON SUCTION LIFT

Atmospheric pressure — which causes liquids to flow into pump impellers—is reduced by about one inch of mercury for each 1,000 ft. of elevation. As a result, the maximum suction lift of any pump is correspondingly reduced if used in higher altitudes.

When buying a water pump, always specify *altitude* in addition to suction conditions. Your Worthington representative can then select a pump with the correct suction characteristic to operate properly at the required altitude.

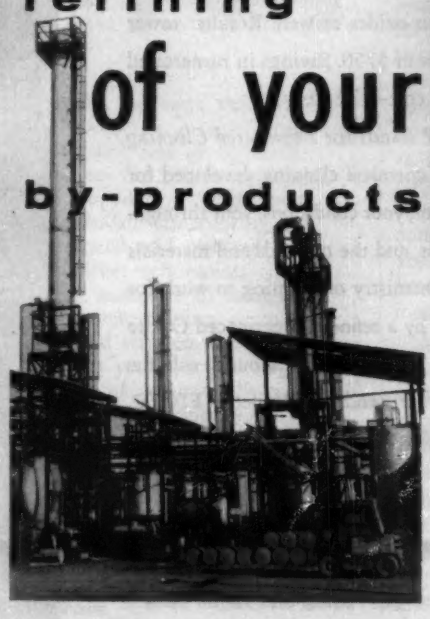
This graph shows how suction lift is affected by altitudes of various U.S. cities.

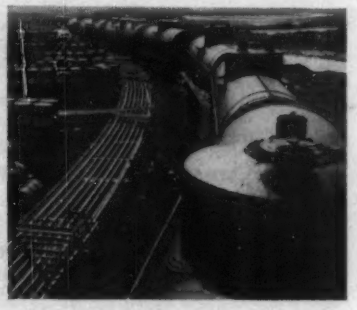


For assistance in solving problems in the operation and maintenance of centrifugal pumps and for useful facts and figures on their selection and installation send for our handy Centrifugal Pump Clinic folder. Write: Worthington Corp., Section 21-1, Harrison, N. J.

WORTHINGTON

refining of your by-products





The facilities and experience of Truland may be employed advantageously for the economical upgrading and disposal of solvent mixtures and organic by-products. Our technically trained personnel are available to discuss the refining of any solvent mixture or organic by-product.

Send *for new booklet which describes our operation.*

TRULAND CHEMICAL COMPANY
EAST RUTHERFORD, NEW JERSEY
Division of The Trubek Laboratories

TRULAND

DU PONT *Petroleum Chemicals* NEWS

Number 87 in a Series of Bulletins for the Petroleum Industry

MAY 1958

Technical bulletin service provides latest information on additives

More than basic product literature, we believe, is needed to keep our customers posted on the latest developments in petroleum additives . . . their applications, handling, and effectiveness.

We therefore maintain an extensive technical memorandum service. Hundreds of separate memoranda have been published and made available to refiners. If you have any particular questions about the use of additives, the chances are good that this comprehensive Du Pont technical service can help you answer them. Here's why . . .

AS SOON AS a new Technical Memorandum is published, copies are distributed.

Technical memos issued by the Du Pont Petroleum Chemicals Division are based largely on extensive and exacting research work at our Petroleum Laboratory. A wide range of typical refinery fuel and lubricant stocks are used in our testing program to assure that the results will have practical application in the field.

"LIFE IN A LARGE CORPORATION" depicted by new Du Pont booklet

No institution is so representative of 20th Century America's technological progress as the large corporation – because the corporation is but a cross section of American industry. This is the basis of a 32-page booklet recently published by the Du Pont Company.

What is the magnitude of Americans' participation in corporate life? It represents well over a quarter of our total population. The 500 largest U. S. Corporations alone employ nearly 9 million people. When wives and families are included, the total is about 35 million dependent on the corporate pay check, plus an estimated 10 million stockholders who have a proprietary interest.

This very magnitude of participation, the booklet says, "should set at rest any myth-inspired uneasiness as to whether the corporations' interests parallel those of the public." And since the whole is equal to the sum of its parts, the popular or cartoonists' conception of the "corporation man" is as false as that of the absent-minded professor or the wild-eyed, long-haired scientist. In other words, corporation people are not "types," but a cross section of all the American people. Their culture is the nation's culture, and their ethical and moral standards are the same as those in other institutions of like proportion.

More important, the successful corporation must encourage each *individual* to accomplish the maximum. "Our nation," the booklet maintains, "has grown so large, and its aspirations so great, that there must be some organizational structure to consolidate human and physical resources on a vast scale." The corporation does this job.

A limited number of copies of the booklet is available. If you would like a copy, ask your Petroleum Chemicals representative, or address Du Pont Petroleum Chemicals Division, 2420 Nemours Building, Wilmington 98, Delaware.

ADVERTISEMENT—Prepared for the Petroleum Chemicals Division of E. I. du Pont de Nemours & Company (Inc.)

OVER

DU PONT *Petroleum Chemicals* NEWS

CONTINUED

Tech Memos

Many subjects covered

The subjects of our technical memos range all the way from new methods for the safe handling of tetraethyl lead to the benefits of additives in heavy fuels. One recent memo, for example, covers the color specifications for military gasolines; another the dispersancy of carbon blacks by Fuel Oil Additive No. 2. There are memos concerning the stability of jet fuels, the performance of FOA-2 in railroad diesel fuels, the advantages of combining additives for

unusual effectiveness or to solve special problems, the octane requirements of new model cars, and the design characteristics of fuel injection systems.

Still other memos discuss the vapor pressures of current commercial gasolines, car manufacturers' fuel recommendations, and such operational problems as diesel injector sticking, valve burning, heating oil nozzle plugging, and a wide range of other topics.

Market forecasts, too

Another valuable service which is provided refiners by the Du Pont Petroleum Chemicals Division is the "Du Pont Quarterly Review and Forecast of Motor Fuel."

These Du Pont market forecasts contain up-to-the-minute figures and charts on current demand and market trends for both motor and aviation gasolines. They can be extremely useful to you as an aid in your planning.

For more information about our technical memo and market forecast services, address your request to the nearest Petroleum Chemicals Division sales office listed at the right of this page.

CENTRAL REGION MANAGER

DONALD W. FRISON, formerly manager of the Petroleum Chemicals Division's Mid-Continent Region, is now manager of the Division's Central Region. His office is in Chicago.

He has been with the Du Pont Company since 1947, starting as manager of the Mid-Continent District Laboratory. In 1951 he moved to Wilmington, as technical assistant to the director of sales. Later he became assistant manager of sales promotion and then assistant to the sales manager, before moving to Tulsa in 1954 as assistant regional manager.

Before joining Du Pont, Mr. Frison was associated with the Florida State Department of Agriculture and its petroleum products laboratory.

He has a B.S. degree in chemistry from Stetson University, and is a member of the Society of Automotive Engineers and American Petroleum Institute. During World War II he was a petroleum officer in the U. S. Navy Bureau of Ships and was engaged in tanker loadings on the East Coast.

Mr. Frison succeeds Earl G. Bennett, who is now manager of the Petroleum Chemicals Division's Eastern Region, with headquarters in New York City.

New booklet describes Du Pont DMF Antistall Additive

Du Pont DMF has proved remarkably effective as a gasoline additive for preventing engine stalls due to carburetor icing.

This effectiveness is due to DMF's favorable gasoline-water solubility and its characteristic of reducing the freezing point of water. When gasoline contains a small amount of DMF, the additive mixes with any water which may condense out of the air in the carburetor. In the water, it acts as a positive antifreeze. Thus it offers refiners and marketers a simple, convenient, and economical way to provide antistall protection.

Comprehensive booklet

A new Du Pont publication discusses DMF in detail. Its application and performance, and laboratory test data, are described. The booklet provides also complete data on the additive's physical and chemical properties, toxicity data and shipping and handling instructions.

A copy of this new booklet on DMF is yours for the asking. Just address your request to any of our sales offices below:

SALES OFFICES

Chicago 3—8 So. Michigan Ave. . . . RAndolph 6-8630
Cleveland 15—25 Prospect Ave. . . . SUperior 1-1363
Houston 2—
705 Bank of Commerce Bldg. . . . . CApitol 5-1151
Los Angeles 17—612 So. Flower St. . MAdison 5-1691
New York 20—
1270 Ave. of the Americas . . . . . COlumbus 5-2342
Philadelphia 2—3 Penn Center Plaza . LOcust 8-3531
Pittsburgh 22—1 Gateway Center . . . ATlantic 1-2933
San Francisco 4—111 Sutter St. . . . . EXbrook 2-6230
Seattle 3—4003 Aurora Ave. . . . . MElrose 6977
Tulsa 1—1811 So. Baltimore Ave. . . . . LUther 5-5578
In Canada—Du Pont Company of Canada (1956) Limited, Petroleum Chemicals, 85 Eglinton Ave. East, **Toronto 12**—Ontario . . . . . HUdson 1-6461
In Other Countries—Organic Chemicals Department, Export Division, 7447 Nemours Bldg., Wilmington 98, Del., OLympia 4-5121, Ext. 2962.

DU PONT
REG. U. S. PAT. OFF.

Better Things for Better Living
. . . through Chemistry

Du Pont Tetraethyl Lead and other Petroleum Additives

ADVERTISEMENT—Prepared for the Petroleum Chemicals Division of E. I. du Pont de Nemours & Company (Inc.)

OVER

A-6763

Printed in U. S. A.

If Oil Could Speak

If oil could speak it would have many fascinating truths to tell the non-oil public—truths that would win thousands of new friends for the oil industry.

But, oil can't speak—you can. You, as an individual, can win many new friends for the oil industry if you will pass the true facts on to your non-oil industry friends.

Here are some of those true facts. They are being presented for one purpose: To keep you posted on your industry, so you can tell the story oil is unable to relate.

Read these facts. You will find them informative—and interesting.

Is the Oil Industry Aiding Education?

Hundreds of oil companies contribute millions of dollars every year to secondary schools, privately endowed colleges and state universities. To give but one example, the Esso Education Foundation recently announced a wide variety of grants to 84 privately supported colleges and universities to stimulate science teaching at the elementary, secondary, college and graduate school levels. This is being done under a special three-year $1.5 million program, of which the first part has been put into effect. The new grants are in addition to 345 other grants totaling more than $1.3 million which the Foundation gave last year to educational institutions.

Is the 27½ Percent Depletion Provision a "Windfall"?

Not by any stretch of the imagination. Here is ample proof: If an oil operator is lucky and can drill a successful well, the tax rule says he can deduct 27½ percent of his gross proceeds, for income tax purposes—provided this is not more than 50 percent of the net. Say the operator is lucky and hits oil (his chances are one out of nine), and his gross for the first year is $10,000. But, it costs him $7,000 to produce this income—leaving a net of $3,000. The operator's tax-free income is not $2,750 (27½ percent of $10,000), but only 50 percent of $3,000—or $1,500.

How Much Gasoline Does the U. S. Public Use?

Every second of each day of the year, more than 1,770 gallons of gasoline was consumed by the nation's automobiles, buses, trucks, planes, boats and other gasoline powered units during 1956. Taking the lead in the consumption of this record-breaking 56 billion gallons of fuel was California. Consumers in that state burned up a total of 5.3 billion gallons. Texas ranked second with a total consumption of 4.5 billion gallons, while New York, in third place, burned a total of 3.7 billion gallons.

Why So Much Concern About Gasoline Taxes?

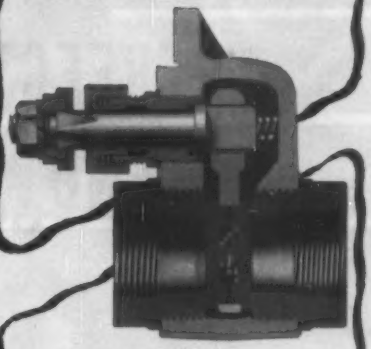
Because they prove conclusively that once government starts taxing a service or commodity, there is virtually no limit to which it will ultimately go—and thus, the buying public should watch such taxes closely. When most states started imposing taxes in the early 20s, the levy was usually 1 cent a gallon or, at the most, 2 cents. There was no federal tax. Now the states impose an average of 5.8 cents per gallon of gasoline. The highest state is Oklahoma with 7.5 cents, the lowest Missouri with 3 cents. And a 3-cent federal tax goes on top of that. In many states, taxes add a third or more to the cost of gasoline.

FULL-FLOW

Okadee

VALVES

NON-LUBRICATED



POSITIVE

STOP

FOR

- Steam
- Air
- Ammonia
- CO_2
- Gasoline
- Propane
- Styrene
- Butadiene
- Lube Oils
- Jet Fuels

Available in Stainless Steel or Steel, Chemically Nickel Coated

You can select Okadee Valves for flow by pipe size—and get full-flow and positive shut-off with virtually any liquids and gases.

Quick-opening, metal-to-metal disc valves and seats require no lubrication—virtually no maintenance for hundreds of thousands of operations . . . Real valve *performance* and *service*.

FACTS AND FIGURES

. . . on Okadee Valves will be sent promptly on request. Sizes ½" to 8"; A.S.A. dimensions; screwed or flanged. Valve seats and discs Stellite or stainless steel; your choice of operators.

- Write for Bulletin CP6

Okadee COMPANY

332 SOUTH MICHIGAN AVENUE

CHICAGO 4, ILLINOIS

For more data on advertised products, use Readers' Service Cards, last page.

THE PERFECT BLEND...

for dependable deliveries of NATURAL GASOLINE

Whatever the Grade, Whatever the Volume,
WHEN, WHERE and the WAY *you* want it!

WARREN

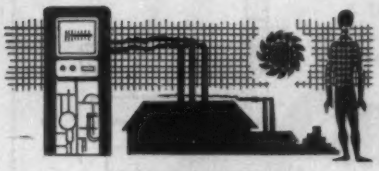
PETROLEUM CORPORATION

TULSA, OKLAHOMA • Cable Addresses: STAYOLENE, WARREN

EXPORT TERMINALS: CORPUS CHRISTI, PORT ARTHUR, BAYTOWN, TEXAS CITY AND WARRENGAS, HOUSTON, TEXAS, SAN PEDRO, CALIF.

What's Happening . . .

. . . in the Industry



New devices being studied as . . .

Clamp-Down On Auto Exhausts Sought

Induction device, direct-flame afterburner, or new gasoline composition may be the answer.

One of the industries most perplexing and costliest problems is air pollution, in terms of both preventive measures and litigation. It is costing about $65 a year for every man, woman, and child living in urban areas. Dr. Haldon A. Leedy, director of Armour Research Foundation of Illinois Institute of Technology, gives a conservative estimate of $4-billion dollars annually for air pollution.

In the Chicago area alone, the cost is estimated at approximately $250 million dollars annually, Leedy pointed out.

The Los Angeles County Air Pollution Control District and the Air Pollution Foundation, San Marino, Calif., are conducting a frontal assault on this stigma. During the fiscal year 1956-57, the APCD continued to cut into smog as sources of pollution were identified and reduced. A substantial reduction was noted in the severity and frequency of smog episodes, although the symptoms were detected over a wider area as population, industry, and traffic expanded.

From here on, however, APCD predicts that only small degrees of further improvement can be anticipated until a major break-through is achieved in control of the auto exhaust.

In itself the discovery of a method for reducing the smog forming characteristics of auto exhaust will not end the problem. The remedy must be available at a reasonable price; the legal requirements for its application must be established; and it must be placed in operation upon millions of automobiles. In addition, a program of inspection and enforcement will be necessary if the remedy is a device. The time required for all this to happen after the control is perfected may be from three to five years, according to APCD.

Basic information is being developed to establish the nature of the control device needed, and an attempt has been made to stimulate the development of such control devices. According to the Air Pollution Foundation, now directing its entire scientific research program to solution of the auto exhaust problem, the cost of control by currently proposed methods will probably be in the range of $50 to $85 per year per automobile.

Separate estimates have been made for induction devices, direct-flame and catalytic afterburners, nitrogen oxide eliminators, fuel changes, and combinations of devices with modified fuels.

An induction device would probably cost the average car owner only $12 a year, the Foundation estimated. But since an induction device cuts hydrocarbon emissions only during deceleration, it would effectively reduce smog only if "deceleration hydrocarbons" are far greater smog formers than other hydrocarbons—and while this possibility is not being overlooked in current research, it is believed most unlikely.

Another device which could cost the average motorist less than $50 a

COMPARATIVE ENFORCEMENT ACTIVITY

FISCAL YEARS 1955-56 and 1956-57

FISCAL YEAR	NOTICES ISSUED	CASES FILED	CASES COMPLETED	DISPOSITION OF COMPLETED CASES		
				Convicted	Dismissed	Acquitted
1955-56	3668	2749	2493	2292	141	60
1956-57	3608	3060	2931	2822	81	28

year would be a direct-flame afterburner, the Foundation said, but so far no one has figured out how to build one to burn exhaust gases successfully in a housing small enough to fit under a passenger car. Estimated average cost, should someone solve this imposing engineering problem: $20 a year.

All other methods which have been proposed would entail the use of either a catalyst requiring periodic replacement or a more expensive fuel. Average yearly costs on these were estimated as follows:

Catalytic afterburner, $50; nitrogen oxide eliminators, $55 to $85; an induction device plus a higher cost nonolefinic gasoline, $50.

Because the approach to the exhaust problem has been directed to reducing the oxides of nitrogen which, with hydrocarbons, are a principle contributor to smog, experiments have been made to determine if it is possible to decompose the oxides of nitrogen by catalysis. Results have not been encouraging, but studies are being continued in this field.

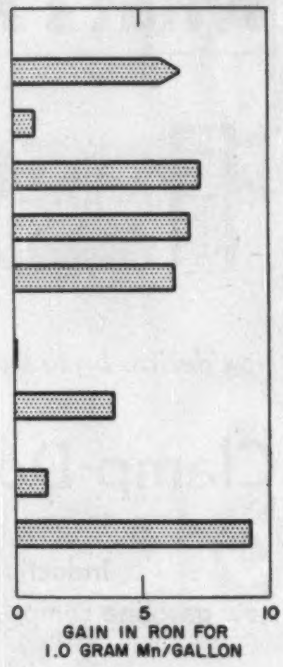
Experiments conducted in the laboratories of the APCD have demonstrated that a strong correlation in terms of eye-irritation and other smog indices exists between the type of gasoline and the exhaust it produces. The observations will require extended study and substantiation.

On the subject of changing gasoline composition, the Foundation noted that in basic studies it is now conducting on exhaust and smog, it expects to be able to clarify the question of whether a fuel containing little or no olefins to begin with would actually produce an exhaust with a lower smog-forming tendency.

Basic data is being compiled to learn what it is in the exhaust that causes smog, when it is emitted, and how it can be controlled.

Dr. W. L. Faith, managing director of the APF, explained: "Keeping auto exhaust controlled, after we learn how to make it stop causing smog, is going to be expensive. It is important to make estimates now, so that we can evaluate the automobile-smog problem in well understood terms—dollars.

HYDROCARBON	RON AT 3.0 ML TEL/GALLON
PARAFFINS	
2,2,4-TRIMETHYLPENTANE (ISOOCTANE)	114.4
n-HEPTANE	47.3
2,3-DIMETHYLPENTANE	104.2
n-HEXANE	79.4
2-METHYLPENTANE	90.4
NAPHTHENES	
CYCLOPENTANE	112.1
METHYLCYCLOPENTANE	104.6
OLEFINS	
2,3-DIMETHYLBUTENE-1	95.2
OCTENE-1	57.4



New Organometallic Antiknock Discovered

A new organometallic antiknock discovered by Ethyl Corporation shows great promise as an agent for octane improvement of gasolines. It is methyl cyclopentadienyl manganese tricarbonyl.

A report on the response of the manganese additive in certain gasoline stocks was made before the 37th annual convention of the Natural Gasoline Association of America in Dallas, April 16.

It appears the most important use of the manganese additive will be as a supplement to the present commercial antiknock—tetraethyl lead (TEL). The new additive is particularly effective in paraffinic gasolines, such as natural gasoline, alkylate, and isomerization products. Therefore, it offers another means of improving octane quality without extensive capital investment and with a cost effectiveness that will be competitive with many alternate means of octane improvement.

Manganese is particularly effective as a supplement to TEL, as shown in the accompanying figure. In general, the greatest response is observed in the paraffins, but the response in naphthenes is almost as good. The olefins show both excellent and relatively poor response; olefins that respond well to TEL also seem to show good response to the manganese.

Once a price ratio between TEL and the new additive has been established, the optimum economic combination of antiknocks can be obtained. At the present time, there is no firm price at which the manganese compound may become available commercially. However, in order to evaluate the potential market, the petroleum industry has been asked to estimate its requirements on the basis of an assumed price of 0.85 cents per gram of Mn in additive form. At this assumed price, the additive costs four times as much as TEL on the basis of metal weight.

The additive can have an effect on the processing route which might be used to gain additional octanes. For example, if the octane quality of some of today's premium gasolines are raised by increasing reformer severity and producing a higher octane reformate, the additive will be of little value for incremental octane improvement. On the other hand, if the increase in antiknock quality is obtained by adding alkylate to the blend, 1 or 2 incremental octane numbers could be obtained at an attractive cost.

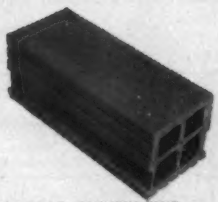
The new additive is potentially

YOUR BEST BUY

for top performance, long life, low upkeep . . .

Leopold

WATER PURIFICATION AND FILTER PLANT EQUIPMENT



LEOPOLD GLAZED TILE FILTER BOTTOMS

• Permanent • Can't corrode • Acid and alkali-resistant • Not subject to tuberculation • Performance proved in over 375 plants with a daily capacity of over 2¾ billion gallons.

LEOPOLD FIBERGLASS-REINFORCED PLASTIC WASH TROUGHS

• Require no painting or other costly maintenance • Easy to handle—inexpensive to install • Resist weather and last indefinitely • Available for all design requirements. Also ideal for weir plates, collector troughs, baffles, etc.

LEOPOLD RUBBER-SEATED BUTTERFLY VALVES

• Provide positive bubble-tight closure • Designed for quick, economical installation, easy operation, minimum upkeep.

LEOPOLD FILTER OPERATING TABLES

• More than 2000 now in service • Furnished in standard models or special designs for individual requirements with electric, hydraulic or pneumatic indicators. Also hydra-pneumatic control systems.

LEOPOLD DRY CHEMICAL FEED MACHINES

• Available in three capacities for fast volume batch feeding of dry chemicals.

Whether adding new plant capacity or modernizing present facilities, it will pay you to use Leopold Filter Plant Equipment. You'll find Leopold products can't be beat for efficiency, long life, and overall economy. Any way you judge them, they're your best buy. We would like to give you valid reasons why—without obligation. Just mail coupon below.

Leopold also manufactures flash and vertical-shaft type mixing equipment.

MAIL COUPON TODAY FOR LITERATURE— COMPLETE DETAILS!

F. B. LEOPOLD CO., INC.
Zelienople, Pa.

Gentlemen:

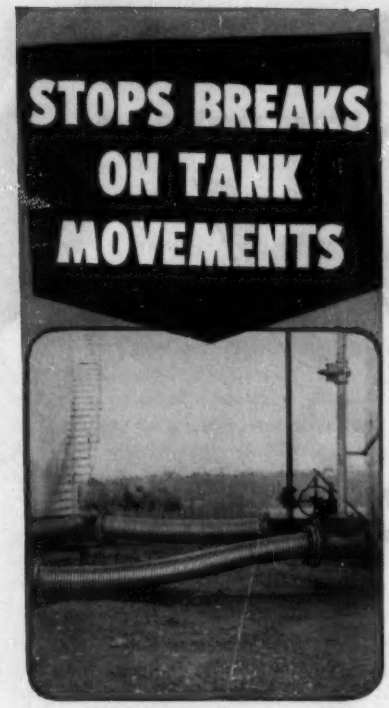
☐ **Please send literature on complete line of Leopold products.**
☐ **Please have representative call.**

Name_____

Affiliation_____

City_____ Zone____ State_____

For more data on advertised products, use Readers' Service Cards, last page.



PENFLEX TUBING

ADDS LEAKPROOF FLEXIBILITY TO RIGID TANK LINES

Moving slowly with expansion, contraction and settling of storage tanks or riding out the tide in unloading tankers, Penflex Tubing has proved its flexibility. It "gives" with temperature changes and settling without breaking . . . withstands crushing, abrasion, exposure . . . yet it stays as tight as a pipe, prevents dangerous leaks and seepage.

Whatever your tubing needs—for oil field, refinery, bulk plant, transportation equipment—let Penflex meet them with *flexible*, corrugated or interlocked tubing available in bronze, galvanized or stainless steel tubing in sizes from 1/8" to 24" I.D. For full data write Pennsylvania Flexible Metallic Tubing Company, Inc., 7207 Powers Lane, Phila. 42.

GET YOUR COPY of this practical, helpful guide to flexible tubing.

PENFLEX

TIGHT AS A PIPE BUT...

FLEXIBLE

What's Happening . . .

very attractive when its costs are compared to other available octane-improvement costs. Using the assumed price of 0.85 cents per gram Mn as additive, octane-improvement costs have been calculated for the additive at various concentration levels and in various blends. The use of 1/8 gram Mn per gallon is competitive cost-wise with current means of octane improvement in all of the combinations of stocks tested.

For the premium-base and regular-base blends, concentrations up to 1.0 gram Mn per gallon give improvement costs that are competitive with costs of alternate means of octane improvement expected in the relatively near future or currently being experienced by some refiners. Blends of reformate with C_5-C_6 isomer or natural gasoline plus butane also show competitive octane improvement costs for manganese concentrations of 1/4 to 1/2 gram per gallon. Incremental improvement costs for a second 1/8 gram Mn per gallon after the first 1/8 gram Mn per gallon is in use also are competitive. However, the second 1/4 gram Mn per gallon and second 1/2 gram Mn per gallon increments generally are not attractive.

Shale-Derived Fuels O. K. for Military

Union Oil Co. recently released data pertaining to shale oil production. They include retorting and refining at rock throughput rates in excess of 900 tons per day, and the shipping of barrel-quantity samples of JP-4 jet fuel and marine diesel fuel to the Navy for evaluation. These shale-derived fuels not only pass all known military specifications but exceed them significantly in numerous important characteristics, as follows:

MILITARY JP-4 JET FUELS

Characteristics	Specification	Shale Product
Aromatics, volume percent	25 max.	17
Freezing point, degrees F.	—76 max.	—78
Heat of combustion, BTU per lb.	18,400 min.	18,634
Sulfur, weight percent	0.4 max.	0.01

MILITARY MARINE DIESEL FUEL

Characteristics	Specification	Shale Product
Cetane number	47 min	55.2
Cloud point, degrees F.	10 max.	—4
Sulfur, weight percent	1.00 max.	0.01

OCAW Proposes New Severance Pay Plan

The Oil, Chemical and Atomic Workers Union is seeking a base of two weeks pay for each year of company service as a future goal for local unions asking severance pay provisions in their contracts.

An additional 10 percent payment of base for each year of age over 40, up to a maximum of triple severance pay at age 60, was suggested at OCAW headquarters.

The union's bargaining program for 1958 demands contract clauses providing for "substantial" severance pay for employes laid off or terminated. That requirement was made mandatory for OCAW's locals, but the amount of pay isn't fixed in a policy statement.

OCAW's research and education department has prepared a suggested pay schedule

OCAW Severance Pay Schedule*

Age When Laid Off	10 Years' Service	15 Years' Service	20 Years' Service	30 Years' Service
40	$2,000	$3,000	$ 4,000	.....
45	3,000	4,500	6,000	.....
50	4,000	6,000	8,000	12,000
54	4,800	7,200	9,600	14,400
58	5,600	8,400	11,200	16,800
60-64	6,000	9,000	12,000	18,000

*Based on employe earning $100 weekly or $2.50 an hour.

For more data on advertised products, use Readers' Service Cards, last page.

NICOMO 1.

A new hydrogen treating catalyst

leads the way!

8%

more desulfurization

No other hydrogen treating catalyst desulfurizes as well as new NICOMO 1. (NICOMO 1. maintains a commercially-proved 8% superiority in desulfurization activity.) No other catalyst offers such a major cost saving. (Because of lower bulk density, you need fewer pounds of NICOMO 1.) Full information in a new booklet. Write on company letterhead for your copy. Or see The Man From Davison.

DAVISON

CHEMICAL COMPANY

Division of W. R. Grace & Co.

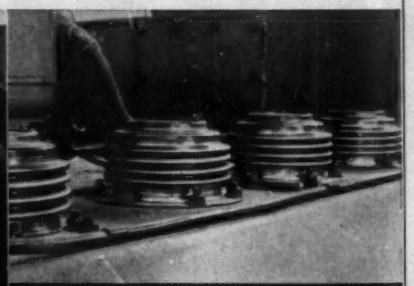
Baltimore 3, Maryland

The answer to your pipe expansion problems

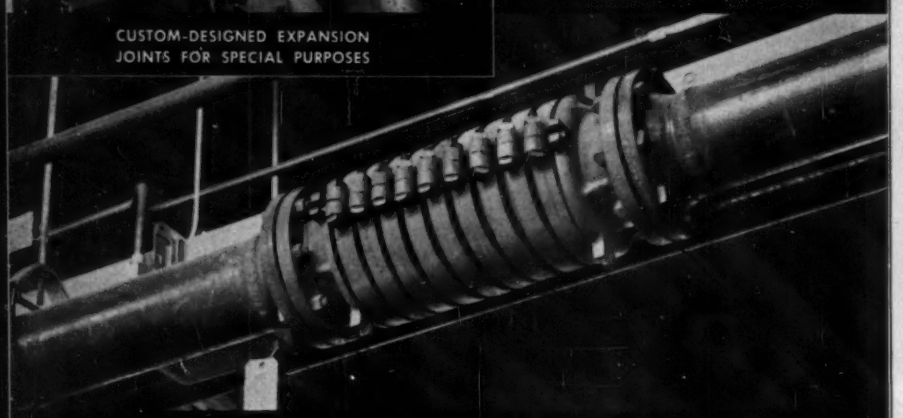
Flexon®

Expansion Joints

CUSTOM-DESIGNED EXPANSION JOINTS FOR SPECIAL PURPOSES



FREE-FLEXING PACKLESS EXPANSION JOINTS



CONTROLLED-FLEXING PACKLESS EXPANSION JOINTS

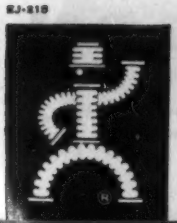
Here's where you'll find the skill and experience to guide your selection of ways to take care of pipe motion problems. Flexon engineering gives you more—more research, more metallurgical care, more service, more "standards" to select from. And all of these add up to expansion joints that you can *install and forget!* Free-flexing and controlled-flexing; pressure-balanced joints and other special designs; all in stainless steel, monel, and other workable alloys.

Member of Expansion Joint Manufacturers Association

Why settle for *less*—when experience shows that you get *more* of everything from Flexon?

TODAY—write for your copy of this 28-page Flexon Expansion Joint Design Guide

EJ-818



Flexonics corporation

EXPANSION JOINT DIVISION • 1336 S. THIRD AVENUE, MAYWOOD, ILLINOIS

EXPANSION JOINTS · METAL HOSE · NON-METALLIC HOSE · BELLOWS · AIRCRAFT COMPONENTS

What's Happening . . .

under the severance plan (see chart). The union's newspaper said the plan is designed to be of particular benefit to men who are too old to find new jobs, and too young to draw a pension.

Free China Sells First Aviation Gas to Australia

Free China's only oil refinery has begun shipping petroleum products to Australia. The move is the result of a ten year contract providing for a first year's shipment of from six to seven million gallons, mostly aviation gas.

Yearly shipments will increase progressively to 16 million gallons in 1959, perhaps to as much as 50 million gallons yearly beginning in 1966. This will total approximately 420 million gallons by the expiration of the 10-year contract in 1968.

The Kaohsiung refinery has a daily capacity of 30,000 bpd of crude oil. Before the contract with Australia was signed, only 18,000 bpd were refined—sufficing for domestic consumption. Heavy oils and asphalt are currently exported to the countries of southeast Asia.

Three grades of gasoline are produced, the 82-88 octane to U. S. government consumers on Taiwan; 80-86 octane, and 70 octane (for trucks). This year the installation of an alkylation unit will make possible the production of aviation gas, known as Octane 100-130; next year a better grade, Octane 115-145, will be produced. Output will be from 300,000 to 400,000 barrels yearly.

The Kaohsiung refinery presently buys its crude oil from the mid-east, principally from Gulf, Mid-East Petroleum, and Sovosco (Mobil). Oil explorations on Taiwan continue—some strikes are reported, but not yet in commercial quantities.

Reference Fuel Gas Available From NBS

Cylinders of standard gas having a certified heating value may now be obtained from the National Bureau of Standards. This recently inaugurated service is the result of a cooperative research effort by the Bureau and the Research Committee of the American Gas Association. Results of the research are a reference gas, certification procedure, and calorimetric test methods acceptable to the utilities that are marketing natural gas as a fuel.

The reference gas is supplied in standard "E" cylinders containing approximately 250 scp of gas at an initial pressure of about 1900 psi, roughly sufficient for 200 calibrations. The gas has a certified heating value of approximately 1,000 Btu/cf. Charges for gas, tank rental, and services have been fixed so that the program is self-supporting.

Request forms and additional information can be obtained by writing directly to National Bureau of Standards, Chemistry Division, Washington 25, D. C.

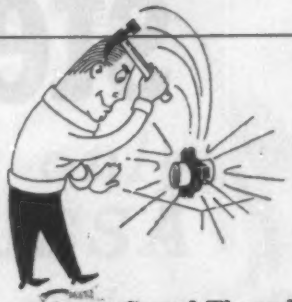
Thai Oil Merger Near

A Thai-Japanese joint corporation for mining and refining on the Thai-Burma border is being planned. The corporation would operate in an area with an esti-

Rocky tells why the Rockwood 603A makes-up without galling

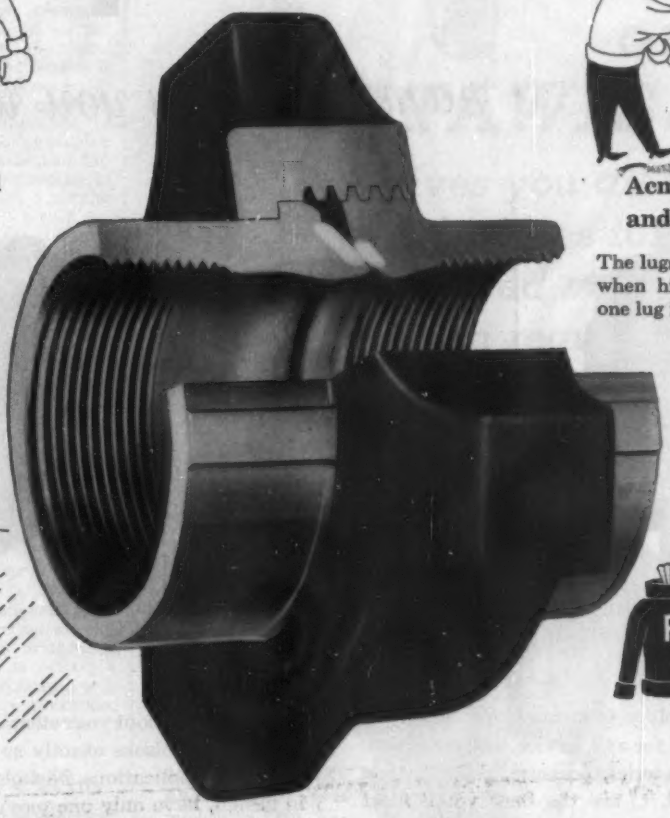
Hardness Differential assures tight seal

The male seat of the 603A is especially treated to make it 150 Brinell harder than the female seat. That means no galling in "make-up." Both seats are made of corrosion-resistant AISI molychrome steel.



Acme Speed Thread and nut extra strong

The lugs will not deform — even when hit with a hammer! And one lug is in position at all times. These speed threads also assure quick "making" and "breaking" in service.



"Rockwoodizing" assures corrosion protection

A special coating process, applied after threading, protects the entire union including the quick-opening Acme thread from corrosion.

Exclusive cold forging process assures interchangeability

Rockwood's exclusive cold forging process results in completely interchangeable parts and higher resistance to tough working conditions.

Get the Union with hardness differential

Strength, interchangeability, corrosion-resistance, Acme speed threads — name it and the Rockwood 603A Tri-Lug Union has it.

Write for complete information. Mail coupon today. The Rockwood 603A Union is tested and listed by Underwriters' Laboratories, Inc.

ROCKWOOD SPRINKLER COMPANY

Distributors in all principal industrial areas

ROCKWOOD

ROCKWOOD SPRINKLER COMPANY
2412 Harlow Street
Worcester 5, Massachusetts

Please send me prices and further data on the Rockwood Unions.

Name.....

Title.....

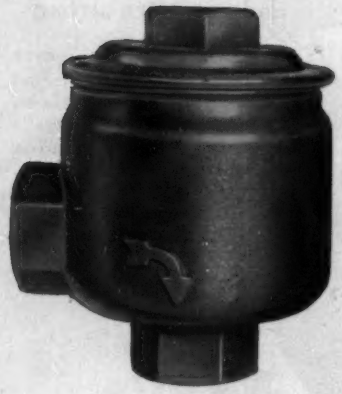
Company.....

City.....*Zone*...*State*.....

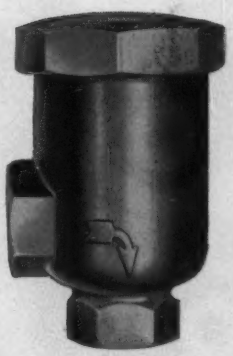
For more data on advertised products, use Readers' Service Cards, last page.

need steam traps?

name the way you want them!



TYPE A



TYPE D

TYPE C

Nicholson can supply your steam traps, exactly as you want them . . . for any service, any condition. Name the size, material, pressure, capacity you need. Types A, D, C are the ones you'll most likely use. Make your selection.

Sizes: A—from ¼" to 1". D—from ¼" to ¾". C—from ½" to 2".

Materials: Cast Iron, Cast Steel and Bronze.

Pressures: A and D—Vacuum to 200 lbs. C—Vacuum to 300 lbs.

Capacities: From two to six times greater orifice area and capacity than other traps of comparable size.

Why wonder about your steam traps . . . when you can get Nicholsons exactly as you need them for your own applications. Nicholson traps are simple in design, have only one moving part . . . a valve that discharges condensate and prevents steam loss.

You get faster warmup, with high air-venting capacity. You eliminate costly leakage, with a powerful shut-tight valve action. You get a trap that's service-tested, when you specify Nicholson. You can try one . . . without obligation! W. H. Nicholson and Company, 12 Oregon St., Wilkes-Barre, Pa. Sales and engineering offices in 98 principal cities.

NICHOLSON

of Wilkes-Barre

For more data on advertised products, use Readers' Service Cards, last page.

mated two billion tons of shale oil deposits, according to surveys made by Kaigai Gijutsu Kyoryoku Kaisha, the Overseas Technical Co-operation Co.

The company is expected to be officially formed shortly, according to the latest report from Bangkok.

An over-all purity content of 13.5 percent has been found in the shale oil, but only that part of the total deposit area having a purity content of 26.8 percent will be developed, according to company plans. Of the $24-million required for the development, Japan will export $16-million worth of machinery, while Thailand will pay for the needed $8-million balance.

Japan will be responsible for technical details, and will assume management of the concern in 25 years. The joint plan was proposed by the Thai Shale and Oil Co., which asked the Japanese company to survey ore deposits and map out a mining plan.

At present, the plans call for a yearly output of 1.4 million tons of oil shale. From this, 400,000 barrels of diesel and fuel oils, 1.1 million barrels of gasoline, and other by-products will be produced.

AIChE 50th Anniversary To Feature Unique Program

The American Institute of Chemical Engineers will celebrate its 50th anniversary in Philadelphia, June 22-27, 1958. Theme of this Golden Jubilee Celebration will be "A Look to the Future." Highlight of the meeting will be the unique technical program, summarizing 50 years of chemical engineering progress and taking a searching look at the future.

Leading scientists and engineers from education, industry and government will present more than 80 papers in thirteen different symposia. Designed to attract a wide range of interests the symposia will include papers in basic science, education, engineering, management, and industry.

Gulf Cited by Who's Who

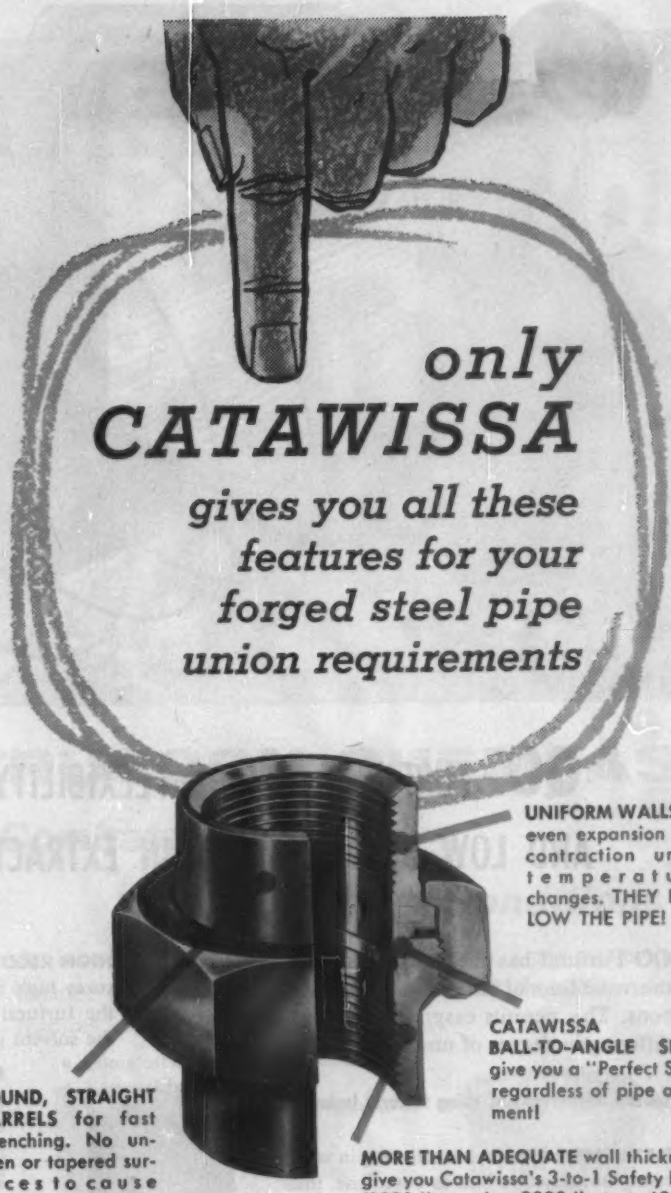
The editors of "Who's Who in America" awarded Gulf Oil Corp. an honorable mention for exceptional corporate educational philanthropy as exemplified by Gulf's aid to education program.

The awards are given biennially in recognition of the most significant corporate gifts which further the American educational system. The awards are based, not only on the size of the gift, but on the uniqueness with which a specific educational program is approached. Gulf's Aid to Education Program includes: Merit Scholarships; Alumnus Gift Matching; Faculty Salary Supplementation; Direct Grants to Independent Colleges: Departmental Assistance; Graduate Fellowships.

Standard Oil Offers Aid To Science Teachers

Standard Oil Foundation, Inc. (Indiana), for the first time is awarding a new kind of fellowship to increase the ability of university faculty members in the physical science and engineering fields.

Three one-year fellowships, providing up to $5,000 or more each, have been

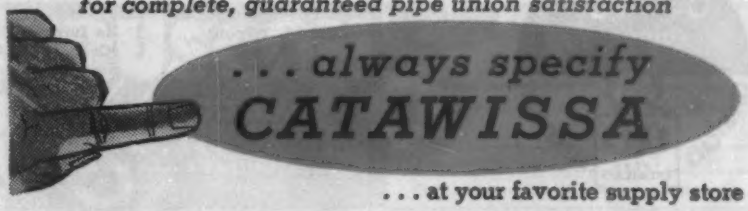

only
CATAWISSA
gives you all these features for your forged steel pipe union requirements
UNIFORM WALLS for even expansion and contraction under temperature changes. THEY FOLLOW THE PIPE!
CATAWISSA BALL-TO-ANGLE SEATS give you a "Perfect Seal" regardless of pipe alignment!
ROUND, STRAIGHT BARRELS for fast wrenching. No uneven or tapered surfaces to cause wrench slips or wrench locking!
MORE THAN ADEQUATE wall thicknesses give you Catawissa's 3-to-1 Safety Factor (3000-lb. service, 9000-lb. test; 6000-lb. service, 18000-lb. test)!

Catawissa Perfect Seal Pipe Unions are made by Union Specialists from 80,000-lb. tensile strength steel (ASTM Spec. A-105-55T, Grade II). Steel forgings from our own forging mill are closely checked for imperfections . . . and finishing on modern, automatic machines with close inspection during and after production give you pipe unions second to none!

Get your free copy of Catalog 56 showing the complete Catawissa line . . . write direct or stop at your favorite supply store.

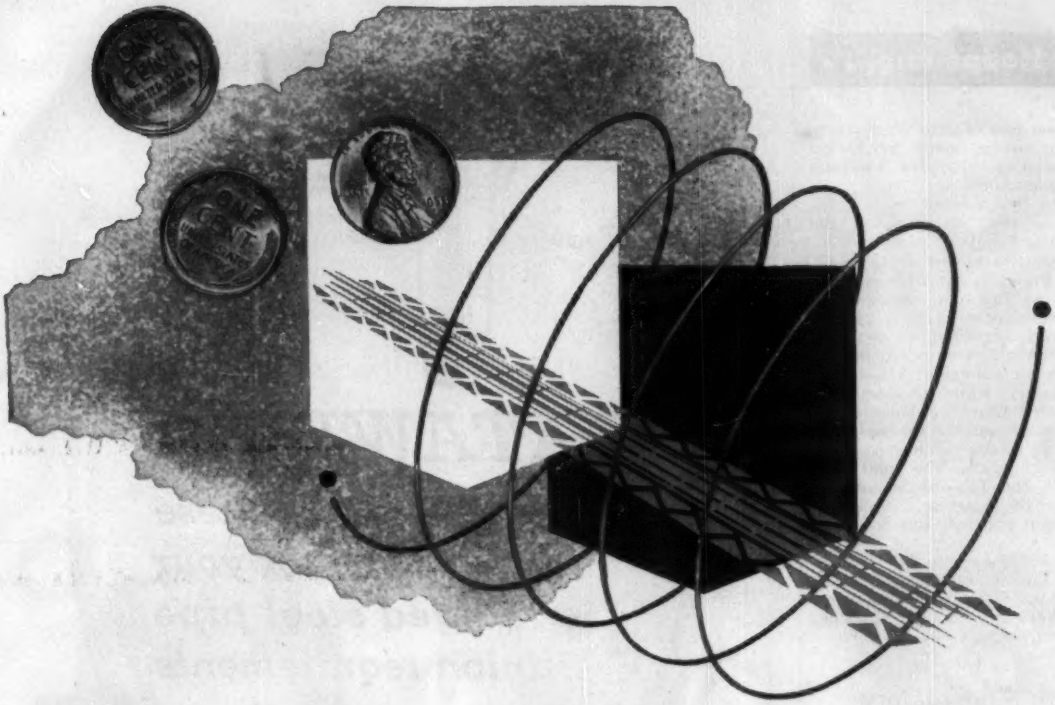
CATAWISSA VALVE & FITTINGS COMPANY • CATAWISSA, PENNA.

for complete, guaranteed pipe union satisfaction



. . . at your favorite supply store

For more data on advertised products, use Readers' Service Cards, last page.



QO® FURFURAL OFFERS FLEXIBILITY, HIGH RECOVERY, AND LOW SOLVENT COST IN EXTRACTION OF BUTADIENE

QO Furfural has the unique ability to alter relative volatilities of butadiene and other C_4 hydrocarbons. This permits easy separation of compounds differing in degree of unsaturation.

Special advantages of using furfural include:

FLEXIBILITY: Furfural is effective in separating butylenes as well as butadiene, thus a furfural unit can be used to prepare both alkylate stock and butadiene. The process employs petroleum-type equipment, which can be adjusted to a variety of operating conditions.

HIGH RECOVERY: Good selectivity of the solvent assures high butadiene recovery; excellent stability of the furfural assures almost quantitative recovery of the solvent itself.

LOW SOLVENT COST: QO Furfural is produced in large quantities from agricultural residues—not from the valuable food or fiber portions of the plant. This helps keep prices low and stable.

QO Furfural is a proved, safe, low cost way of producing butadiene of highest purity. Write for information on extractive distillation and Bulletin 203-A entitled Physical Data on QO Furfural.

The Quaker Oats Company
CHEMICALS DEPARTMENT

The Quaker Oats Company — CHEMICALS — QO — CHEMICALS — DEPARTMENT

340C The Merchandise Mart
Chicago 54, Illinois

Room 540C 120 Wall Street,
New York 5, N. Y.

Room 440C 48 S.E. Hawthorne Blvd.,
Portland 14, Oregon

In the United Kingdom:
Imperial Chemical Industries, Ltd., Billingham, England

In Europe:
Quaker Oats-Graanproducten N. V., Rotterdam, The Netherlands Quaker Oats (France) S. A., 3, Rue Pillet-Will, Paris IX, France; A/S "Ota", Copenhagen, S. Denmark

In Australia:
Swift & Company, Ltd., Sydney

In Japan:
F. Kanematsu & Company, Ltd., Tokyo

awarded the winners for study toward their doctorate degrees. The fellowships will enable the winners to complete work in fields of their choice that will better equip them as educators.

Each fellowship provides a monthly income, according to need, of from $200 to $300 for one year, tuition and laboratory fees, and a $1,000 grant to the university where the winner elects to study.

The winners of the fellowships for the 1958-1959 academic year are: Ivan E. Morse, Jr., mechanical engineering department, Michigan State University; Richard A. Strand, electrical engineering department, Pennsylvania State University, and John A. Weese, enginering mechanics department, Cornell University.

Gamma-Resistant Jet Fuels May Power Atomic Plane

Auxiliary engines in America's first atomic powered plane can be powered by jet fuel resistant to high doses of gamma radiation, according to an Air Force-sponsored research team.

"Saturates in general, and naphthenes in particular, are the best choice as auxiliary fuels for nuclear-powered aircraft," reported Roy E. Thorpe, Shell research chemist, at a meeting of the American Chemical Society. "Fuel components of this type, he said, showed excellent thermal stability under gamma radiation."

The atomic plane's weight may be reduced by eliminating the need for heavy radiation shielding of auxiliary fuel lines and tanks. This would aid designers, already faced with the problem of heavy radiation shielding needed to protect flight crews.

The report also points out that neutrol radiation, also produced by nuclear reactors, may present a problem, and that more research will be necessary to find out its importance.

Shell Development Co.'s Emeryville, Calif., research laboratory was the site of the Air Forces project.

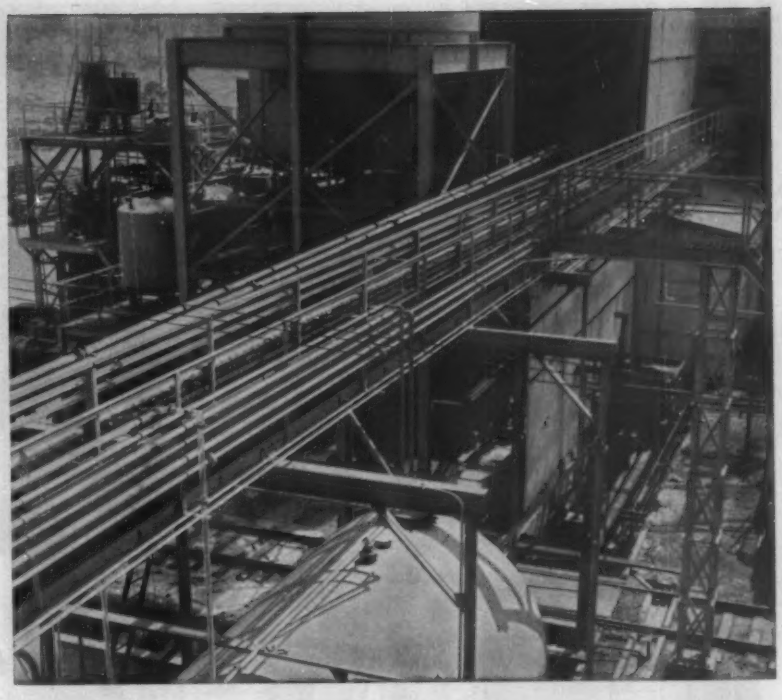
Catalyst Treating Process Cuts Replacement Costs

California Research Corp. has developed a new catalyst treating process that can cut in half the cost of replacing worn-out catalyst in a moving-bed cracker, according to A. L. Lyman, president of the company.

This improvement is accomplished through a complex chemical and physical process that prevents the rapid deterioration of catalyst beads which occurs when they grind against each other or come in violent contact with the interior surfaces of the equipment, Lyman said.

The process is being used in eight plants ranging in capacity from 13,000 bpd to 25,000 bpd. Amount of catalyst required in the plants has been reduced by at least 43 percent and as much as 77 percent. Catalyst savings expected for a 15,000-bpd plant, air lift or bucket, should range from $135,000 to $250,000 per year, Lyman said. Complete installation of the process in a 20,000-bpd plant will cost only about $5,000, including engineering, installation and materials. Installation can be accomplished in most plants without a shutdown.

Operating costs are less than $5 per day



TRUSCON CHEMFAST

Combats Extreme Corrosion Conditions!

An investment in Chemfast protection now will pay you maintenance dividends for years to come. Check these Chemfast features . . . they'll save money for you!

- Contains Devran Epoxy Resin
- Resists Chemicals
- Exceptionally durable for interior or exterior
- Resists excessive abrasion
- High Operating Temperatures — Up to 350°F.
- Available in functional, morale-building colors
- Chemical resistance effective on wood, metal and masonry surfaces
- Apply by conventional methods including hot spray

Truscon qualified representatives will provide prompt inspection, color guidance and consultation without obligation.

Send Coupon Now For Full Information!

TRUSCON Laboratories
Industrial Maintenance
Division of Devoe & Raynolds Co., Inc.
Detroit 11, Michigan

TRUSCON Laboratories
1700 Caniff, Dept. A-2
Detroit 11, Michigan

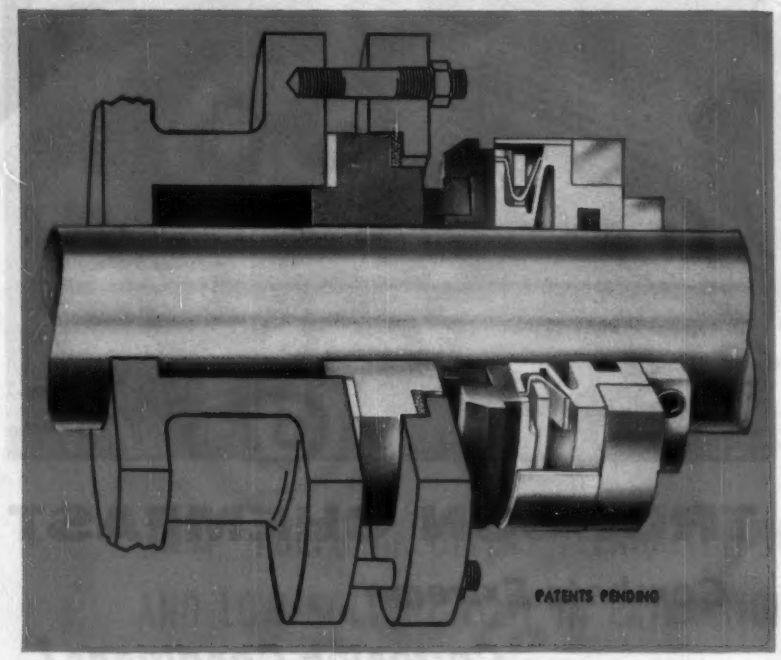
☐ Send information on Chemfast.
☐ Have Representative call for appt.

Name _____
Address _____
City _____ Zone ____ State ____

For more data on advertised products, use Readers' Service Cards, last page.

BELMONT
"Chemical" SEAL

(PRESSURE BALANCED TEFLON BELLOWS DESIGN)



- **Greatest immunity to corrosion**
- **Longest useful life**
- **More economical than any other design or materials combination**

Customers report unsurpassed performance in difficult corrosive service with the BELMONT Chemical SEAL. A rotating mechanical seal, it employs a pressure balanced TEFLON* bellows design, free from the weaknesses (corrosion and flexural fatigue) of conventional metallic bellows.

Rotating with the shaft, only bearing surface is between rotating and stationary seal faces. No scoring of shafts. Will work satisfactorily on shafts previously scored by other seals or conventional packing.

Provides a perfect fluid seal without high friction load on the shaft and attendant high power costs. Greatly reduces hazards of handling flammable, explosive, corrosive and toxic liquids, and will handle abrasive slurries (when proper flushing means are provided). For pressures at the seal up to 100 psi at 75° C. Temperatures to 100° C at 75 psi. Standard sizes to fit shafts from ⅛" to 2¼".

Ask Your Belmont Distributor or write for Catalog T-57.

The Belmont Packing and Rubber Company
Butler & Sepviva Streets, Phila. 37, Pa.

* du Pont Trademark

BELMONT

What's Happening. . .

for materials per hundred tons of catalyst, and manpower requirements and utilities costs are negligible, it was reported.

Lyman also pointed out that many plants limited by coke burning rates can have capacity increased 5 to 10 percent with the new catalyst treating process, as a result of faster catalyst circulation. "When increased plant capacity is compared to the $300-$400 per bpd cost of erecting new plants, capital savings become obvious," he said.

Electronic Monitor Ready

A fully transistorized, automatic process monitoring system has been completely installed at the Casper, Wyo., refinery of Socony Mobil Oil Co., Inc. The electronic system is designed to monitor the operation of a new catalytic reformer producing 3500 bpd of high-octane gasoline. The system employs transistors and other semiconductor components in place of vacuum tubes. The solid state circuitry is said to eliminate electronic failure which until recently had restricted the use of industrial data systems for continuous process monitoring and control.

The system records temperatures, pressures, flows, and other key physical variables from 200 points within the catalytic reformer, scanning the information sources at a rate of four a second. The detailed record of process performance is typed automatically in desired physical units, such as degrees Fahrenheit or pounds per square inch, at regular intervals selected by plant operators.

Plant Outlay Up in 1956

The Commerce Department's 1956 Annual Survey of Manufacturers shows that refining companies spent $153½ million more than they did in 1955 for new plants and equipment. Total expenditures in 1956 were $687 million compared to $533¼ million in 1955.

Outlay in 1956 for additions to plants and new structures was $519 million. Costs for new machinery and equipment were $168 million.

In 1955 new structures and additions to plants amounted to $365½ million. Outlay for new equipment and machinery was $618 million. In 1954 total expenditures were $656 million compared to $316¼ million in 1947.

Bureau of Mines Outlines Oil Recovery, Shale Future

Bureau of Mines research on petroleum, natural gas, and helium will be directed primarily toward conservation of natural resources, according to Marling J. Ankeny, bureau director.

For the fiscal year 1959, the bureau has already received approval by the House on a request for $25,334,000. This compares with $25,853,000 for the current year.

Ankeny, in telling of the bureaus plans in shale oil development and oil recovery, said, "We anticipate that our studies of increasing oil recovery by water flooding and the engineering evaluations we make of oil reservoir performance will be the

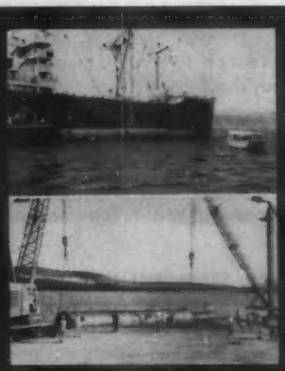
For more data on advertised products, use Readers' Service Cards, last page.

Here is the refinery Procon built for The Texas Company (West Indies) Limited 3 miles south of Santiago de Cuba. Inset shows complete refinery area early in construction period.

Creative Construction

how **PROCON** put it to work for Texaco in Cuba

Procon trained 85% of the Cuban workmen in construction technicalities.



Crude atmospheric column, prefabricated in the States, was floated ashore in 2 hours—a saving of much time and cost.

Solid rock was encountered at a number of locations, required blasting to sink foundations, underground piping.

It's a pretty exacting business at best, building a refinery from scratch. Procon did this one the hard way, meeting and beating the challenges of: a site difficult for access by land . . . 85% of Cuban workmen needed training in technicalities of construction . . . applying the creative solutions to the problems shown in the pictures you see here. If you have a refinery in mind . . . or a petrochemical plant, or a chemical plant, or individual process units for any of these . . . you can be sure of top-flight construction, anywhere in the world, when you call on Procon to do the job.

PROCON *International, S. A.*

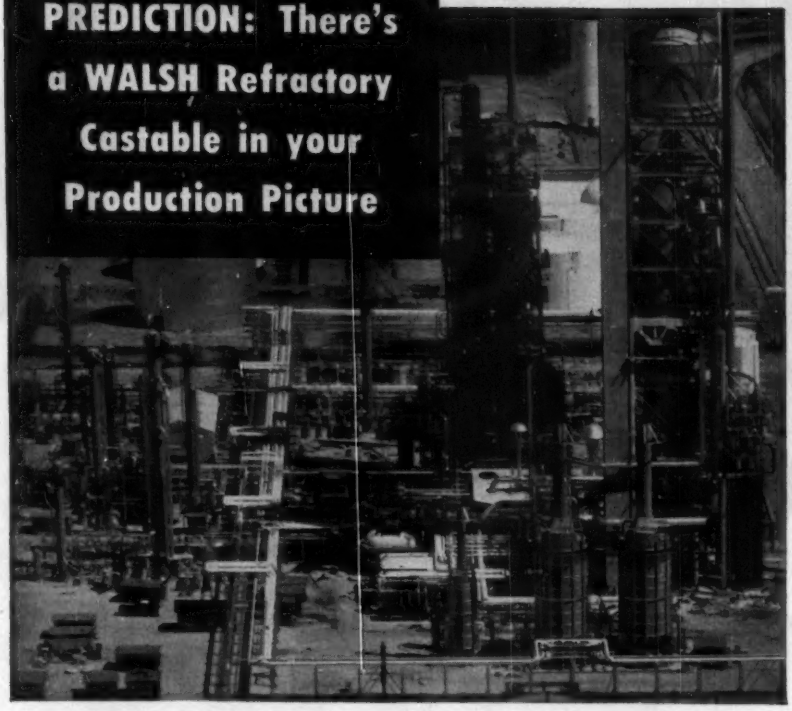
JOSE A. SACO, NO. 6, SANTIAGO DE CUBA

PROCON INCORPORATED, DES PLAINES, ILLINOIS, U. S. A.
PROCON (CANADA) LIMITED, TORONTO 18, ONTARIO, CANADA
PROCON (GREAT BRITAIN) LIMITED, LONDON, W. C. 2, ENGLAND

WORLD-WIDE CONSTRUCTION FOR THE PETROLEUM, PETROCHEMICAL, AND CHEMICAL INDUSTRIES

For more data on advertised products, use Readers' Service Cards, last page.

PREDICTION: There's a WALSH Refractory Castable in your Production Picture



Assurance Of New Highs In Performance At Lower Cost

Whether your refractory castable practice calls for a two-component lining or consideration of a "one shot" system later on—you'll find the right Walsh product for your purpose. Modern as tomorrow, every Walsh Castable offers absolute homogeneity—the result of production control methods that insure the perfect union of all ingredients for efficient service throughout a longer life. The whole money-saving story is available from your nearest Walsh representative. Or, write us direct, today.

WALSH EXTRA STRENGTH H & B CASTABLE (Service Type) For highly abrasion-resistant, monolithic, working linings in catalytic regenerators, reactors, and other refinery equipment.

WALSH LITE WATE INSULATING CASTABLE NO. 50. Features high bulk density while retaining a low K factor. Recommended for back-up use in two-component linings.

WALSH LITE WATE INSULATING CASTABLE NO. 70. Higher strength and a low K factor makes this insulating castable highly desirable for "one shot" linings.

All Walsh Castables are characterized by extreme "flowability", excellent nozzle compaction, lower rebound loss . . . plus greater strength, better bond . . . throughout the complete temperature range.

Send for New Illustrated Castable Bulletin

WALSH
REFRACTORIES CORPORATION
101 Ferry Street · St. Louis 7, Missouri
SPECIALISTS IN REFRACTORIES OF HIGH BULK DENSITY AND LOW POROSITY

What's Happening . . .

most beneficial in Midwestern and Western fields."

He added that petroleum utilization research, centering largely on basic chemistry and thermodynamics, will continue to provide background data for industry on the composition and properties of both crude petroleum and the products derived from it. Sulfur and nitrogen compounds, which are most harmful, will be the subject of intensified study in fiscal year 1959.

The increasing industrial interest in the production of oil from shale points up the importance of research in this field. The bureau anticipates that its work in 1959 on the composition and structure of organic substances in shale, and shale oil to which it can be converted, will be basic in future operations.

Ankeny pointed out that the experimental oil-shale facilities near Rifle, Colo., will continue to be maintained in a standby condition.

Product Value Study Ranks Refining Eighth

Petroleum refining moved up to eighth place during 1956 in the Department of Commerce report, ranking industries by value of goods increased through manufacture. It ranked ninth in 1955, sixteenth in 1954, and eighth in 1947.

The report, just released, showed that petroleum refining's "unadjusted" value added by manufacture totaled $2¾ billion. The adjusted value was $3 billion.

"Unadjusted" is the value of goods shipped (excluding sales) during the year, less the cost of materials, supplies, fuel, electric energy, and contract work. "Adjusted" is the value added by merchandising, plus the net change in finished products and work-in-process inventories between the beginning and end of the year to the unadjusted figure.

The survey estimated employment in refinings manufacturing establishments during 1956 at 154,000. In 1955 the figure was 151,000, compared to 153,000 in 1954 and 146,000 in 1947.

Octanes Remain Stable

Gasoline on sale at service stations in April was unchanged from the national weighted averages in February and March of 98.5 octane number for premium and 91.1 octane number for regular, according to the latest monthly survey of antiknock quality compiled by Ethyl Corp. Compared with April 1957, the premium average was .8 octane number higher and the regular average was .5 octane number higher.

Average tetraethyl lead contents in April were 2.49 ml per gallon of premium gasoline and 1.85 ml per gallon of regular gasoline.

For companies marketing more than one grade of premium, the survey showed a range of 100.4 to 102.8 octane number for the highest grade, on the basis of 40 samples in 20 cities.

Twenty-four of the 57 cities in Ethyl's survey reported increases over March in the average octane number of their premium gasoline, one by 0.5 octane number. Twenty cities reported decreases and 13 cities were unchanged. In regular gasoline, 28 cities reported increases over March in their average antiknock quality, two of

For more data on advertised products, use Readers' Service Cards, last page.

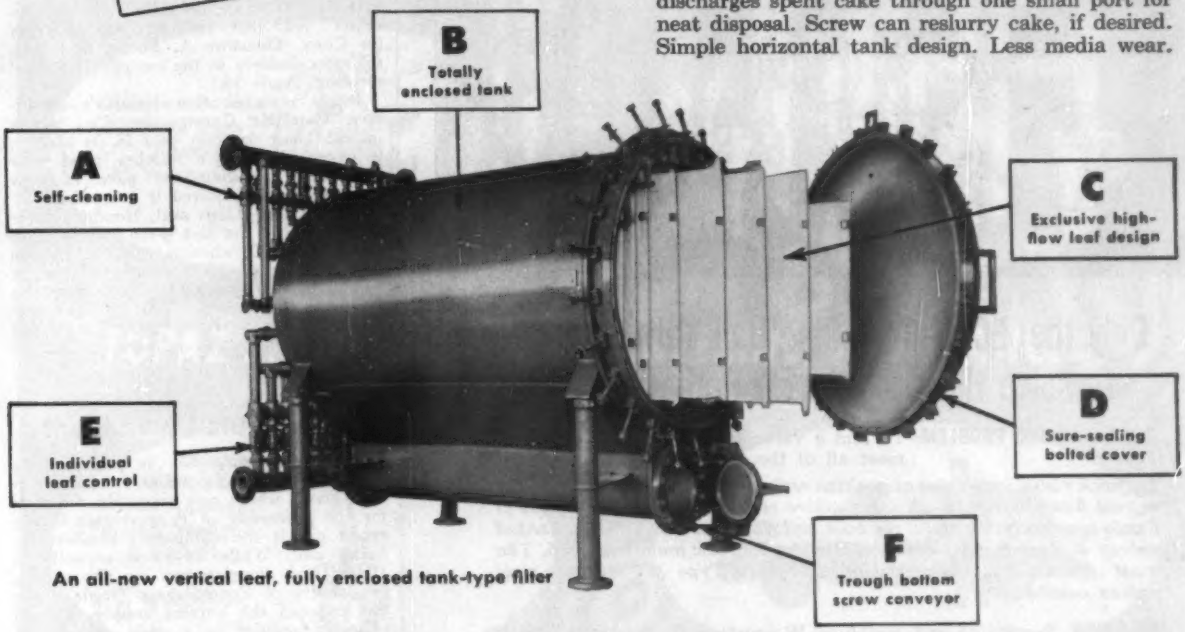
SPARKLER *Presents* NEW VERTICAL PLATE FILTER . . . MODEL RSC

EXCLUSIVE OPERATING ADVANTAGES

Greater Clarity Control—Sight glasses, sample cocks and individual control valves for each leaf provide continuous clarity control. Should any leaf not function properly, it may be shut off without interrupting operation.

Minimum Manpower Required—A single non-skilled individual is capable of operating a large battery of RSC filters including filter aid addition, cleaning, precoating and supervising.

Faster Cleaning, Easier Maintenance—A 560 sq. ft. Model RSC can be cleaned in 10-15 minutes (30-45 minutes total down-time). Leaves are sprayed clean individually. Screw conveyor in trough bottom discharges spent cake through one small port for neat disposal. Screw can reslurry cake, if desired. Simple horizontal tank design. Less media wear.



An all-new vertical leaf, fully enclosed tank-type filter

Exclusive Design Features

A Internal sprays sluice filter. Can be independently valved for individual operation under low pressure conditions.

B No leaking, dripping or air-borne contamination. Assures a neat filter station with clean, sanitary service. Filter may be insulated to minimize heat loss. Can be installed in low headroom, small floor space areas.

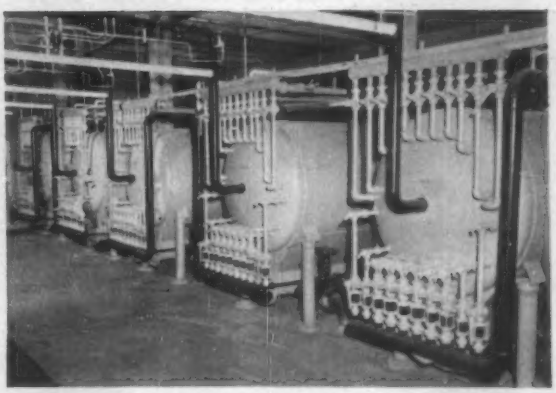
C Vertical rectangular leaf design assures maximum flow per filtering area and even precoating. Unexcelled rigidity and durability. Hung on roller carriages for easy individual inspection or removal, no bolts or fastenings. Self-sealing in filter. Stainless steel leaves covered with long-life synthetic cloth or stainless steel wire screens.

D Bolted cover on double-hung hinge provides full access to interior without leaf removal. Hydraulic quick-opening cover optional.

E Individual plate outlet control valves, sight glasses and sample cocks. Any plate or plates may be shut off without removing filter from service.

F Trough bottom with screw conveyor discharges cake neatly and quickly without opening tank. Cake can be reslurried if desired.

SIZES UP TO 1020 SQ. FT. OF FILTERING AREA



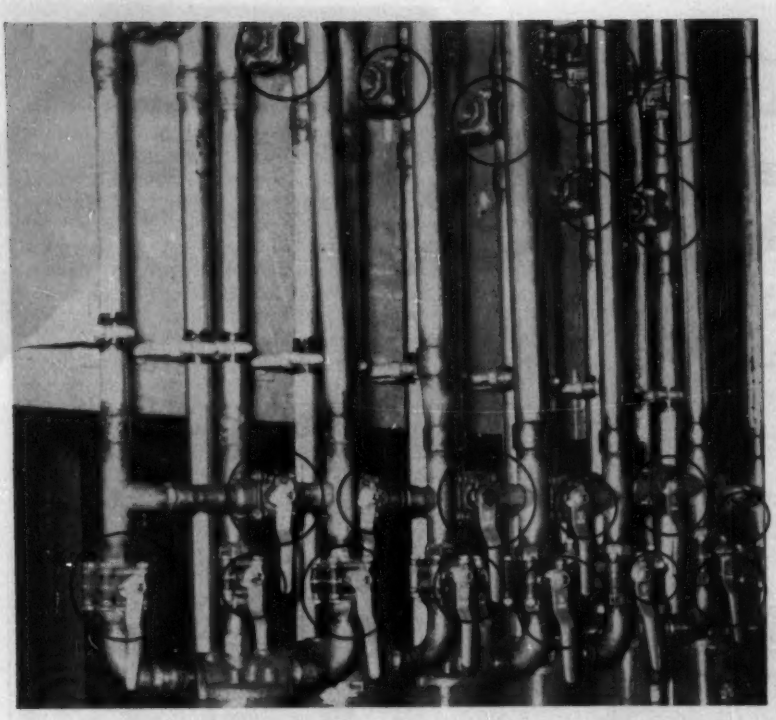
A battery of five 300 sq. ft. Model RSC filters in operation

SPARKLER

MANUFACTURING CO., Mundelein, Illinois, U.S.A.

Sparkler International Ltd., Leliegracht 9, Amsterdam-C, Holland
Manufacturing plants in Canada, Holland, Italy and Australia

Filtration engineering and manufacturing exclusively for over 30 years



Only the ECON-O-"MISER" Ball Valve was able to solve this problem for PathéColor, Inc.

THE PROBLEM: To find a valve that would meet all of the following requirements:

1. Quick visual indication of position and quarter turn operation. 2. Excellent flow characteristics and positive shut-off. 3. The advantages of flange construction without the bulk and weight of conventional flanged valves. 4. Easy & quick disassembling for low cost maintenance. 5. The most compact and economical installation of Type 316 stainless steel valves possible.

SOLUTION: *Specifying* and *installing* Worcester's Econ-o-"miser" Ball Valve. In so doing Pathé Color found a valve that provides a positive seal, a flanged construction much more compact than conventional valves that could be socket welded. In addition many unions and companion flanges were eliminated with the overall result that savings on this installation alone amounted to many hundreds of dollars.

Valves available, ¼"-2", in following standard materials*: Bronze, Aluminum Bronze, Aluminum, Carbon Steel and Types 303 and 316 Stainless Steel. Standard Seat and O-Ring materials*: Buna-N, Neoprene, and Teflon.

**Other materials available on request.*

For further information and descriptive literature write to:

WORCESTER VALVE CO., INC.

16 PARKER STREET • WORCESTER, MASS.

What's Happening. . .

them by 0.5 octane number. Twenty-two cities reported decreases while seven cities were unchanged.

Compared with the nationwide premium average of 98.5 octane number, six cities reported premium averages of 99 octane number or higher. In regular gasoline, 19 cities showed average octane ratings of 91.5 octane number or higher, compared with the national weighted average of 91.1 octane number.

Houdry Sees Upswing in '58

First quarter operations this year indicate that 1958 should be a "considerably better" year than 1957 for Houdry Process Corp. Theodore A. Burtis, president, told stockholders at the company's annual meeting, April 10.

Burtis reported that Houdry's subsidiary, Catalytic Construction Co., which in 1957 had the best year in its history, is expected to have another good year in 1958, providing the pace of new business so far acquired is maintained.

A year ago, Burtis said, Houdry's operating losses in the first three months were about $380,000, whereas estimates for the first quarter of 1958 show earnings of $130,000. Income taxes will reduce this figure to less than half, Burtis said, and warned that quarterly figures are not necessarily indicative of earnings on an annual basis.

Sinclair Shuts Down Plant

Sinclair Refining Co. is discontinuing its Wellsville, N.Y., refinery operations. The plant, which was primarily designed for the processing of Pennsylvania Grade crude oil, is the company's smallest refining unit. While its rated capacity is 10,000 bpd, the progressively diminishing availability of Pennsylvania Grade crude has reduced the current supply through existing facilities to a daily average of approximately 3500 bpd.

A recent fire that seriously damaged one of the main processing units precludes the supplementing of the crude supply with crudes from other sources. This circumstance, together with other economic factors, made the shutdown imperative, it was stated.

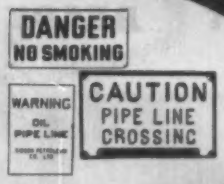
Aluminum Cans For Esso

Esso Standard Oil Co. soon will begin using one-quart aluminum cans at the motor-oil packing plant of its Baltimore refinery in accordance with terms of the company's contract with Reynolds Metals Co., announced last September. At present, Esso is purchasing one-quart aluminum cans from Reynolds for its Bayonne refinery motor-oil packaging plant. An option permitted Esso to purchase a year's requirements for the Baltimore packaging operations, if the company later decided to do so. It is expected that aluminum containers will be in use on Esso's one-quart packaging line at Baltimore about the middle of May. The Baltimore requirements have been tentatively estimated at 20 to 25 million one-quart cans. Previously, some aluminum motor-oil cans had been produced for experimental purposes.

For more data on advertised products, use Readers' Service Cards, last page.

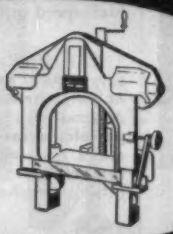
L&M Industrial Plant Signs Junction Boxes Sole Distributors

L&M Dura-Glaze Aluminum Plate Safety Signs



TOPAZ . . . LEADER IN DEPENDABLE PRODUCTS

Guillotine Saws
National Saws
Agent for
E. H. Wachs Co.



- check valves
- torches
- pipe locators
- saddles and reducers

TOPAZ . . . LEADER IN ENGINEERING ASSISTANCE

Stopple Application, Hot Tapping, Pigging, Wedge-Lock-Plugs Agent for T. D. Williamson, Inc.

TOPAZ . . . LEADER IN FAST SERVICE

Topaz sales engineers will assist your Engineering Department and supervise field personnel in solving unusual pipeline problems. Topaz service includes internal cleaning, inspection, testing and furnishing all equipment on a lease, contract or purchase basis.

ToPaz

TOD PAZDRAL Pipeline Specialties

2525 South Boulevard • Houston 6, Texas • Day Phone: JA 2-1403 • Night Phone: MA 3-5680

PUT READY COOL® IN YOUR Maintenance Picture!

Air Conditioning For A Furnace? Ridiculous!

Now stop and think a minute. Couldn't you often use a high velocity of cold air to speed cooling of heated vessels? A 60 Ton* entirely portable READY COOL produces 18,000 CFM of air 25 to 30 degrees below ambient temperature even on the hottest summer days at an operating cost of 26¢ per ton/hour.

RESULTS ARE AMAZING!

CASE I One large petrochemical plant in East Texas was dissatisfied with the 70 hours lost in cooling down their cracking heaters for maintenance and repair, and secured a 50 Ton READY COOL. The unit was used as a blower until 600 degrees F. was reached, then the air conditioning was added. There was no brick spalling. The cooling down period was reduced to 20 hours average. Worker efficiency was increased approximately 85% working in 75 degrees instead of 120. ***They reported the heaters were repaired and back on stream in less time than previously required for cooling alone.***

CASE II Another Chemical Plant said their cooling down time was reduced from 48 hours to 8½ using a READY COOL.

CASE III A third Plant stated their payroll was reduced an average of 40% in hot areas where they used their 40 Ton model and that, with less down time, ***it paid out each time they used it.***

FIGURE YOUR OWN SAVINGS

ADD
A. Present cooling down time ____ Hrs.
B. Average work time in Unit ____ Hrs.
TOTAL ____ Hrs.

MULTIPLY
Down-time loss per hour ____ Hrs.
$____ Hrs.

PLUS
C. PAYROLL FOR MAINTENANCE $____ Hrs.
TOTAL COST $____ Hrs.

The Savings with READY COOL will be approximately 60% of this figure. (75% of "A"; 40% of "B" & "C")

* $6,900 FOB New Orleans, La.

Patents Pending

READY COOL® INC. PORTABLE ICE AIR CONDITIONERS

2301 American Bank Building
New Orleans, Louisiana

Model	#5820	#5830	#5840	#5850	#5860
Tons of Refrigeration	20	30	40	50	60
C.F.M.	6,000	7,500	12,000	15,000	18,000
BTU Per Hour Capacity	240,000	360,000	480,000	600,000	720,000

All Units Trailer Mounted; Gasoline or Electric Powered

–Changing Times–

Level of imports has been cut as deeply as U. S. can afford says A. L. Nickerson, Socony Mobil president. **Oversupply won't be problem it is today,** said Nickerson. Reasons he gave: **exploration activity is up all over the world, Russian oil** will return to world market **in great quantities,** development in **politically instable Middle East** will slow. His answer to problem: **industry should spend $115-billion on facilities by 1968,** money to come from profits, recovery of capital, and new investments.

Lube oils of the future for high-speed aircraft must operate at 400-600 F. to withstand greatly increased operating temperatures, says a U. S. Air Force scientist. **Mineral lubes,** good at bulk temperatures up to 250 F. **are not adequate** for futures high-speed aircraft.

A. P. Hobbs, Dow Chemical spokesman, says **natural gas liquids will be only source of petrochemical raw materials in future.** As food requirements and population grow, **petroleum must make chemicals formerly made from agricultural products.** Demand for methane, ethane, and ethylene and other petrochemicals will soar, says Hobbs.

Phillips Petroleum Co. has **consolidated under one manager** all phases of its **operations in Canada.** M. R. Hayes will manage Phillips' foreign department Canadian operations with **headquarters in Calgary, Alberta.**

Phillips Petroleum Co. is installing two **"atom smashers" at its Bartlesville research center,** which will enable company to **investigate nuclear radiation effects on** petroleum and petrochemical products and **processes.**

Tidewater Oil Co. has acquired **10,000 square miles in concessions in West Pakistan.** Skelly Oil Co. and Kewanee Oil Co. are equal partners in the venture. **Tidewater is operator. Pakistan is 25 percent working partner** assuming proportionate share of risk, and will share any profits 50-50.

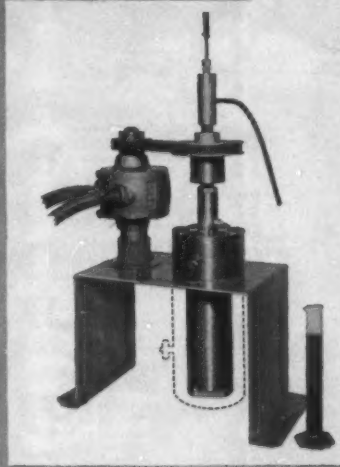
Standard Oil Co. (N. J.) paid **five times more to governments last year than dividends to stockholders.** Payments for duties, taxes, etc., were **over $2.3-billion, amounting to $11.66 per share.** Consolidated earnings for '57 were $805-million.

Senate Committee on Government operations issued staff memo on **"Reorganization of Federal Science Activities."** Plan would place **within Dept. of Science and Technology,** the National Science Foundation, Bureau of Standards, Office of Technical Services (Commerce) and others.

American Petrofina and its operating division, **American Petrofina Co. of Texas have moved** to Mercantile Dallas Bldg., 1807 Commerce St., Dallas.

Allied Chemical & Dye Corp. **has changed its name to Allied Chemical Corp.** New name is intended to reflect broad nature of company's position in chemical industry **without singling out any particular division.**

NEW... HIGH PRESSURE RESEARCH EQUIPMENT BY AUTOCLAVE ENGINEERS



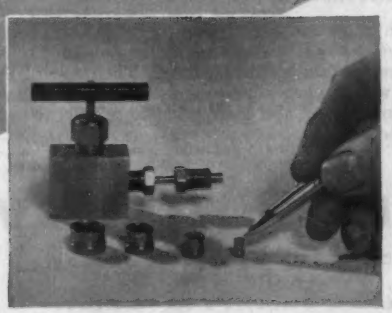
0.3 lit. STIRRED AUTOCLAVE. New bench-scale, high pressure clave complete with agitator and drive, cooling coils, electric heating, dip tube, charging opening, gas openings. Pressure rating 5000 p.s.i. at 650°F. All wetted parts made of 316 s.s. Electric or Air drive.

NEW ROCKER SHAKER. Off-center pivot point provides both rocking and shaking type of agitation. Adjustable arc, variable speed are other advantages of this new rocker-shaker autoclave.

HOFER MAGNE DASH. High powered, magnetically agitated pressure vessel for large capacity or highly viscous reactions. Solenoid action external to vessel provides positive 20 lb. thrust of agitator in each direction. No springs, no stuffing box, no external moving parts. Units with even greater thrust are available.

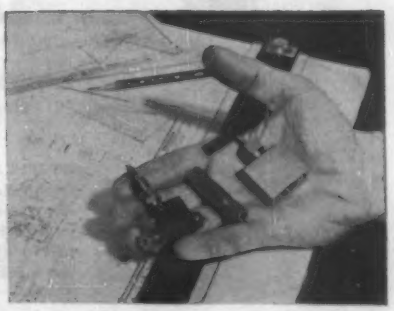
AUTOCLAVE ENGINEERS, INC

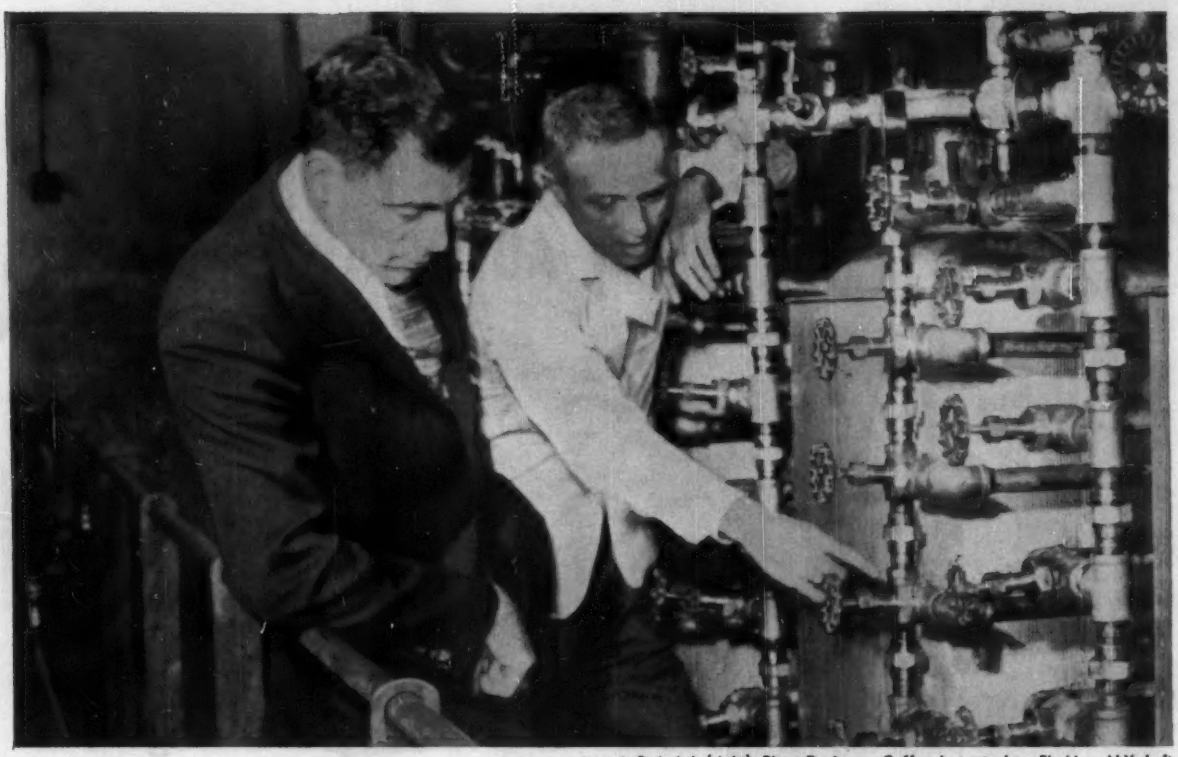
2940 WEST 22nd STREET, ERIE, PENNSYLVANIA



AUTOCLAVE TUBING VALVES. Equipped with Ermeto® fast connection **Type 316 Stainless Steel** sleeves for corrosion resistance.

⅛" O.D. TUBING VALVES and FITTINGS. For pressures of 5000 p.s.i. on instrumentation, sampling and bench-scale set-ups. Stainless steel construction. Ermeto® sleeve connection eliminates threading, swaging, flaring, welding.





Joseph Smindak (right), Plant Engineer, Coffee Instants, Inc., Flushing, N.Y. Left, Michael De Piano, N.Y. representative, Cooper Alloy Corp. Foreground, Cooper Alloy 1" stainless Union Bonnet Globe Valves.

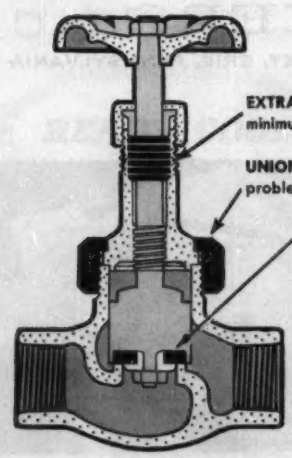
SMINDAK of COFFEE INSTANTS, INC.

Tells why he specifies Cooper Alloy for stainless steel valves and fittings

Q. Mr. Smindak, why does Coffee Instants, one of the nation's leading instant coffee processors, use stainless valves and fittings in processing their product?
A. To protect product purity, a must with us as with most other food processors. Contact with other metals can degrade flavor and aroma; stainless steel does not.

Q. Why Cooper Alloy?
A. Because of the special Cooper Alloy construction features I find combined in no other brand. On these Cooper Alloy union bonnet globe valves, for example, we like the ease of operation and the low maintenance; the fact that it removes a threaded joint from product contact; and in particular, the extra-deep square-compression stuffing box which reduces maintenance, gives a tighter seal at stem. Then too, the excellent service we get from Cooper Alloy sales people and distributors.

Q. You don't find these features in any competing valve?
A. Frankly, not one has them all. That's why, for our stainless valves *and fittings*, we insist on Cooper Alloy.


EXTRA-DEEP STUFFING BOX holds minimum 6 turns Blue African asbestos
UNION BONNET JOINT eliminates problems found in screwed-in bonnets
RETAINED RENEWABLE DISC for tight seal and long life

COOPER ALLOY Figure 15RD Globe Valve, inside screw rising stem, 200-lb. service, screwed ends, renewable retained disc of composition you specify.

YEARS AHEAD IN DESIGN SUPERIORITY! No matter what your valve type—globes, gates, angles, checks, or Y's—the Cooper Alloy model's outstanding design features will be important to you. Cooper Alloy, with 35 years of pioneering experience in stainless steel, does not merely adapt existing brass and iron valve patterns; it creates valves *designed to be cast in stainless!* **Check the special design features of valve shown at left.**

As the little CA man below is saying: "*You Can Tell A Cooper Alloy Valve As Far As You Can See It!*" Write today for *your* copy of our folder "Design Factors In Stainless Steel Valves." The Cooper Alloy distributor near you will be glad to show you the complete line of Cooper Alloy valves *and fittings*, and their advantages. He can serve you promptly from local stocks.

COOPER ALLOY
Corporation • Hillside, New Jersey
VALVE & FITTING DIVISION
THIRTY-FIVE YEARS OF STAINLESS STEEL PIONEERING

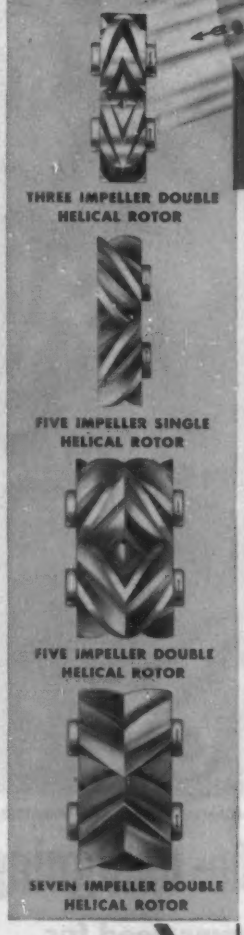
MEETINGS CALENDAR

1958 MAY	
19–21	National Fire Protection Assn., 62nd Annual Meeting, Palmer House, Chicago.
21	Chemical Market Research Assn. Meeting, Hotel Statler, N.Y.
21–22	Western Petroleum Refiners Assn., West Texas-New Mex., Regional Technical-Industrial Relations Meeting. Hotel Paso del Norte, El Paso, Texas.
25–29	API Pollution Control Association, Annual Meeting, Sheraton Hotel, Philadelphia.
27–29	Short Course in Gas Technology, Texas College of Arts and Industries.
28–29	Rocky Mountain Oil and Gas Assn., Refining Committee Annual Meeting, Cody, Wyo.
31–June 8	Chemical Engineering Exposition and Congress, Frankfort, Germany.
JUNE	
4– 6	American Petroleum Institute, Oil Information Committee Meeting, Sheraton Hotel, Chicago.
9–12	ASME Materials Handling Conference, Public Auditorium, Cleveland.
9–13	Gordon Research Conference, Colby Junior College, New London, N.H.
14–16	American Society for Testing Materials Meeting, Hotel Statler, Boston.
15–19	ASME, Semi-annual meeting, Hotel Statler, Detroit.
16–18	American Association of Cost Engineers, 3rd. Annual meeting, Case Institute, Cleveland.
16–21	Short Course in Statistics Methods for Research Workers in Industry, North Carolina State College.
18–28	Chemical and Petroleum Engineering Exhibition, Olympia, England.
22–27	American Institute of Chemical Engineers, 50th Anniversary Meeting, Bellevue-Stratford Hotel, Philadelphia.
22–28	American Society For Testing Materials, Annual Meeting and Exhibit, Hotel Statler, Boston.
25–26	Western Petroleum Refiners Assn., Mid-Continent Regional Technical-Industrial Relations Meeting, Broadview Hotel, Wichita, Kan.
JULY	
24–25	Fifth Annual Symposium on Computers and Data Processing, Albany Hotel, Denver.
AUG.	
18–21	American Institute of Mechanical Engineers, Heat Transfer Meeting, Northwestern University, Evanston, Ill.
SEPT.	
3– 5	American Petroleum Institute, Oil Information Committee Meeting, Hotel Statler, Boston.
4– 5	American Society of Mechanical Engineers, International Conference on Air Pollution, Hotel Statler, N.Y.
10–12	National Petroleum Assn., 56th Annual Meeting, Traymore Hotel, Atlantic City, N.J.
15–19	American Society of Mechanical Engineers, Process Industries Conference, Hotel Statler, Buffalo, N.Y.
21–24	American Society of Mechanical Engineers, Petroleum Mechanical Engineering Conference, Cosmopolitan Hotel, Denver.
24–25	Western Petroleum Refiners Assn., Rocky Mountain Regional Technical-Industrial Relations Meeting.
28–Oct. 1	American Society of Mechanical Engineers' Power Conference, Hotel Statler, Boston.
OCT.	
1– 2	Western Petroleum Refiners Assn. Third Annual Stream Pollution and Waste Disposal Conference, Lassen Hotel, Wichita.
5– 8	American Institute of Mechanical Engineers, Society of Petroleum Engineers, Fall Meeting, Houston, Site Unreported.
9–10	American Institute of Mechanical Engineers Fuels Meeting, Old Point Comfort Hotel, Old Point Comfort, Va.
13–15	American Gas Assn., Annual Convention, Atlantic City, N. J., Site Unreported.

Kinney®

HELIQUAD® PUMPS

Ask to Pump the "Impossible"


THREE IMPELLER DOUBLE HELICAL ROTOR
FIVE IMPELLER SINGLE HELICAL ROTOR
FIVE IMPELLER DOUBLE HELICAL ROTOR
SEVEN IMPELLER DOUBLE HELICAL ROTOR

KINNEY Heliquad Pumps are designed specifically to handle materials beyond the capabilities of other pumps . . . heavy viscous materials, principally, that pumps of other configurations just do not handle economically. Asphalt, tar, heavy crudes, Bunker and even gasoline are handled efficiently. Heliquads are fixed displacement Pumps and will give metered flow . . . volumetric range from 10 to 2000 gpm.

The economy advantage in the KINNEY Heliquad is based on two factors: 1) freedom from downtime and high maintenance over exceptionally long service life, (many in operation over 20 years); 2) heat economy—Heliquad Pumps move heavy viscous materials at substantially lower temperatures, (the fact the high heat is available doesn't change the fact that btu's cost money).

Heliquad Pumps handle entrained gases and nonlubricating liquids. They make money for you by doing the job other pumps can't do—by keeping production up when other pumps are down. Write for Bulletin L-54 Today!

Get the facts on the pump, and rotor that is best for you.

KINNEY MFG. DIVISION
THE NEW YORK AIR BRAKE COMPANY
3596E WASHINGTON STREET • BOSTON 30 • MASS.

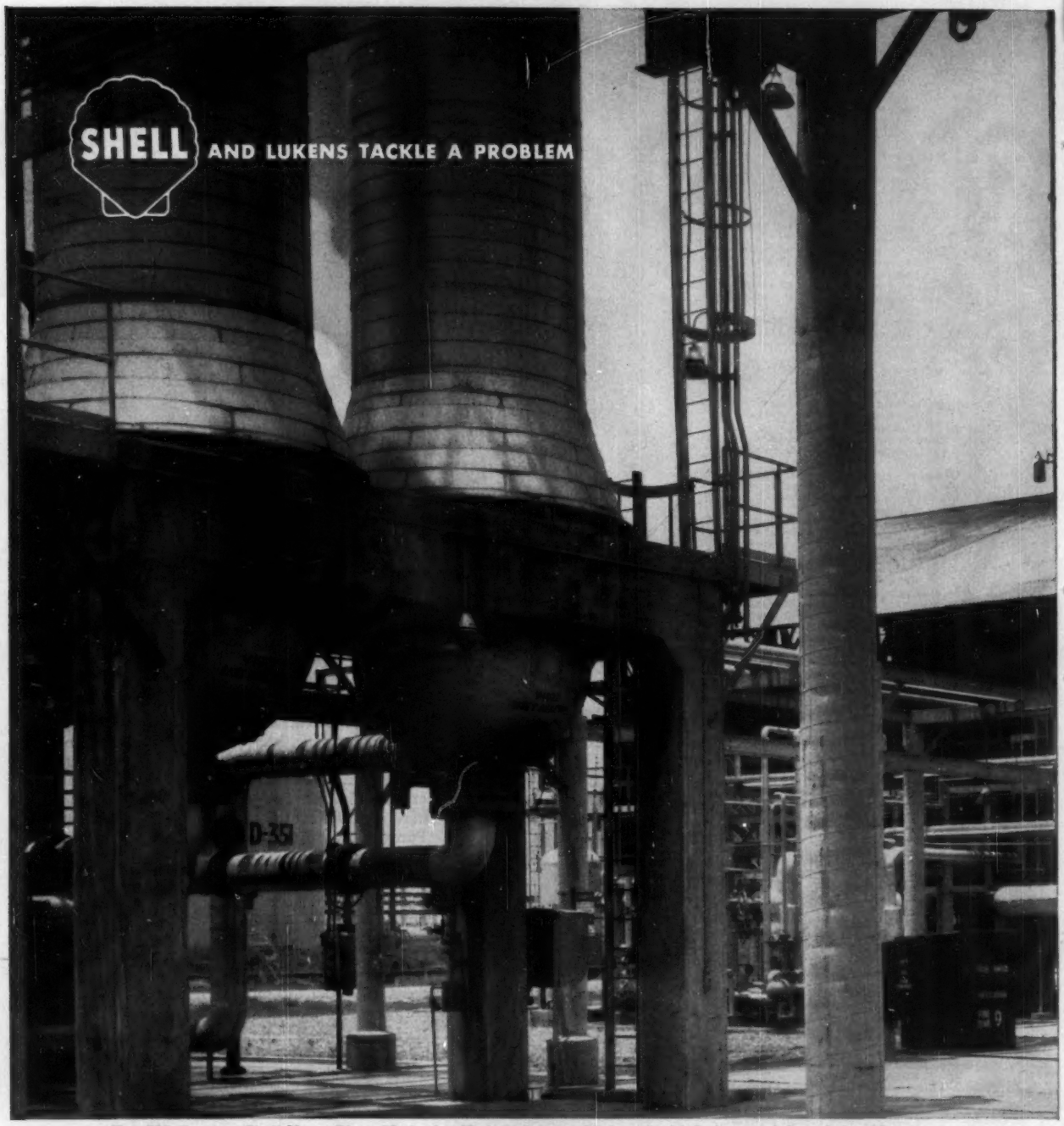
Please send me copy of Bulletin L-54 by return mail.

Name_____

Company_____

Address_____

City_____ Zone____ State_____



Two 78" diameter Shell Vapor-Phase Hydrodesulfurizer reactors fabricated with Lukens stainless-clad steel.

Teamwork pays off – designing desulfurizers and

Flued hemispherical heads answer need for uniform stress patterns

It took teamwork between Lukens and Shell . . . and at this modern Houston, Texas, refinery the results are rewarding.

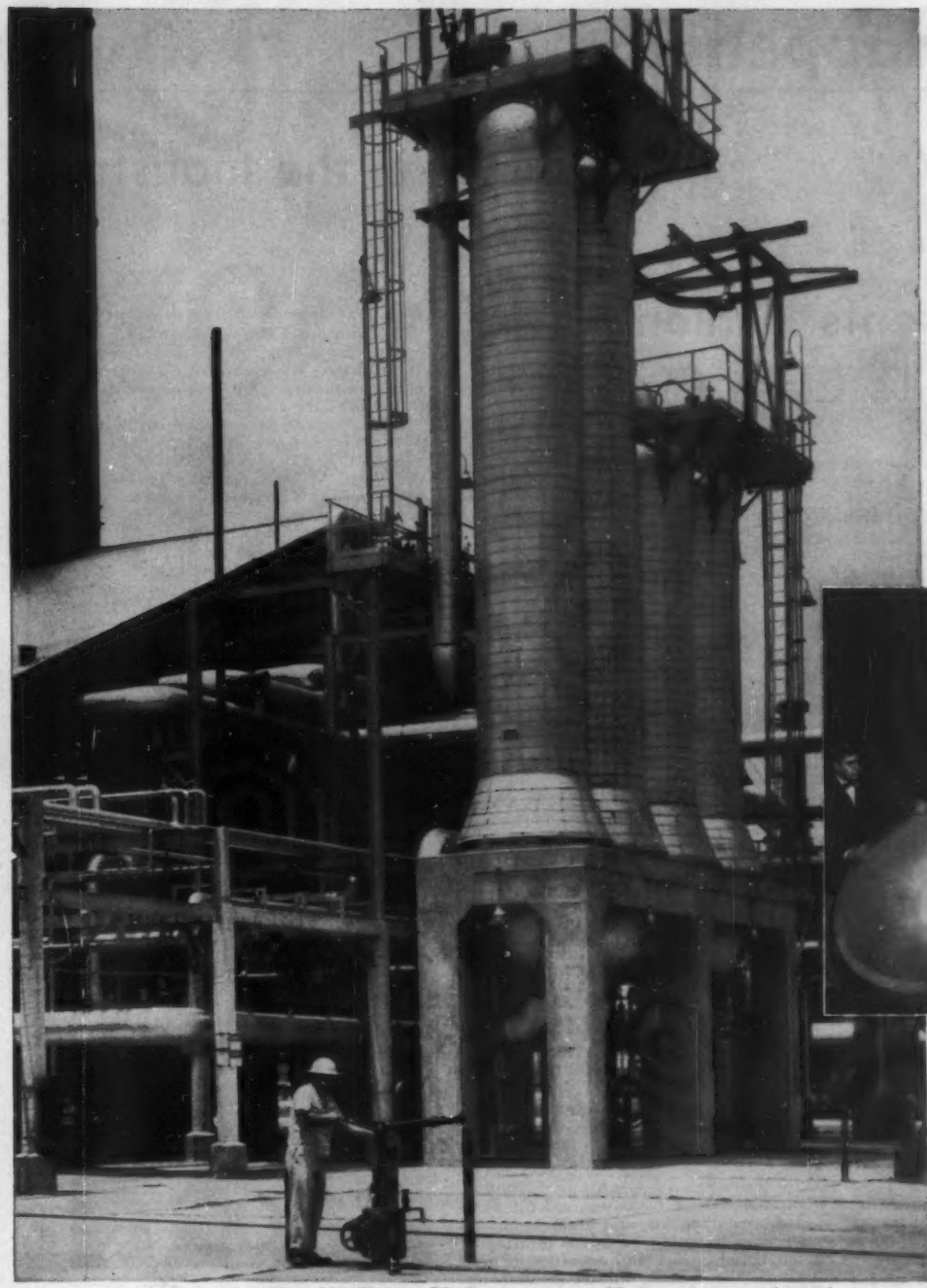
There were separate problems in selecting steels for the Shell V-P Hydrodesulfurizers and Platformers and a common problem of obtaining a more uniform stress pattern in heads of both.

In the 78" diameter V-P Hydrodesulfurizer reactors, Lukens stainless-clad steel with a backing of Lukens A-204 firebox steel provided the required high resistance to hydrogen and hydrogen sulfide attack at elevated temperatures, plus strength and protection against hydrogen embrittlement.

In the 60" diameter Platformer reactors, where design pressure is 800 psi and design temperature is 950 deg. F., Lukens chrome moly steel plate gave still greater strength-temperature handling ability, plus resistance to hydrogen attack.

And by the use of Lukens hemispherical spun and flued heads in both the V-P Hydrodesulfurizer and the Platformer, engineers and production men

For more data on advertised products, use Readers' Service Cards, last page.



Smooth contours and accurate location of the flued openings in these Lukens spun heads matched Shell's critical design needs.

Four 60" diameter Platformer reactors of Lukens chrome moly steel.

reformers with Lukens clad and alloy steels

achieved an outstanding advantage: Uniform stress patterns in the critical flued areas with added assurance of maintenance-free operation at high temperatures and pressures.

Ask your equipment builders about the broad range of Lukens clad, alloy, and carbon steels, or write for "CLAD STEEL EQUIPMENT." Address Manager, Marketing Service, Room 125, Lukens Steel Company, Coatesville, Pa.

This is Lukens clad steel—a solid plate—one side corrosion resistant metal permanently bonded over-all to a rugged, economical backing steel.

LUKENS

Helping industry choose steels that fit the job

For more data on advertised products, use Readers' Service Cards, last page.

What's Happening . . .

. . . *Among Men* in the Industry

WPRA Presents Hanlon Award To Union Oil's Clare Gard

Clare D. Gard, former chief process engineer for Union Oil Company of California, has received the Natural Gasoline Association of America's "Hanlon Award Citation" for his contributions to the processing field. The presentation was made at the NGAA's 37th annual convention in Dallas on April 17.

Gard received a B.S. degree in electrical engineering from the University of Southern California in 1917. He joined Union Oil Company of California, in 1921, where his first job dealt with an experimental gasoline plant in which different types of absorber trays and tower packings were being studied. Because of his work the perforated type tray was adopted by Union Oil and was shortly the accepted type for absorbers, strippers and fractionators in most of the plants of that early period.

In 1922 he was transferred to the Gas division of his company as engineering advisor to the gas supervisor. Two years later Gard was transferred to the Gas division offices to become technical assistant to the superintendent of operations. In 1941 he was made chief process engineer for Union Oil and held that position until his retirement nearly a year ago.

The more important projects in which Gard played a leading role are listed as follows:

1. The application of the perforated plate tray to natural gasoline absorption and fractionating columns.

2. The use of water draw-off trays in the fractionating sections of fractionating stills.

3. Continuous sidestream reconditioning of absorption oil, for which a patent was issued in his name.

4. The design and construction of the first LPG plant in California.

5. Stimulated gas lift operations in California and planned and supervised the extensive field and laboratory work which resulted in the substitution of compressed high pressure wet gas for the dry gas then being used. This change made possible tremendous savings in plant equipment and operating expense.

6. Co-designer of the first natural gasoline plant to produce dry ice as a by-product from natural hydrocarbon gas.

7. Conceived and perfected equipment and procedure for calibrating natural gasoline positive displacement meters under actual operating conditions.

8. Was co-designer of the first large scale plant to effect condensate recovery by means of expansion of gas produced at high wellhead pressures and regenerative cooling.

Clare Gard

9. Was a co-developer of the Reid Vapor Pressure-Composition correlation which is used in California as the basis of evaluating the worth of natural gasoline.

In the words of George T. Tennison, NGAA president, Gard received the Hanlon Award "for his individual work and his cooperativeness with others in bringing about better design and operation of natural gasoline plants, his imaginative approach to the solution of problems for which the early text books gave no answer, and for the fundamental advancements in industry techniques which he originated."

In addition to duties for his own company Gard was active in cooperative work with various organizations. He served as a member, or chairman, of the principal technical committees of the California Natural Gasoline Association. He was one of its officers for many years and served as its president in 1944-1945. He still is a member of the CNGA Executive Committee and Board of Directors and was a member of several NGAA technical groups, having served one term as NGAA vice president. He was also active in API and ASTM committees.

E. E. Wall has been named president of The California Oil Co. In assuming leadership of the company, Wall succeeds **B. W. Pickard. W. S. Morris,** Caloil's general sales manager, has been named a vice-president of the company.

Wall brings to his new position 24 years of experience in petroleum marketing with Standard Oil Co. of Calif. During the past two years, he has been general sales manager and vice-president, marketing. He began his oil marketing career in Hawaii after studying at the University of Hawaii, University of Oregon and University of Southern California. Before coming to the East Coast two years ago he was regional manager for Standard of Calif. in that company's Fresno (California) region.

Morris, who attended the U. S. Naval Academy and the University of Pittsburgh, was made credit manager of The California Oil Co. when it first began East Coast operations in 1947. Since that time he also has served as manager of distributor sales before being named general sales manager in 1957.

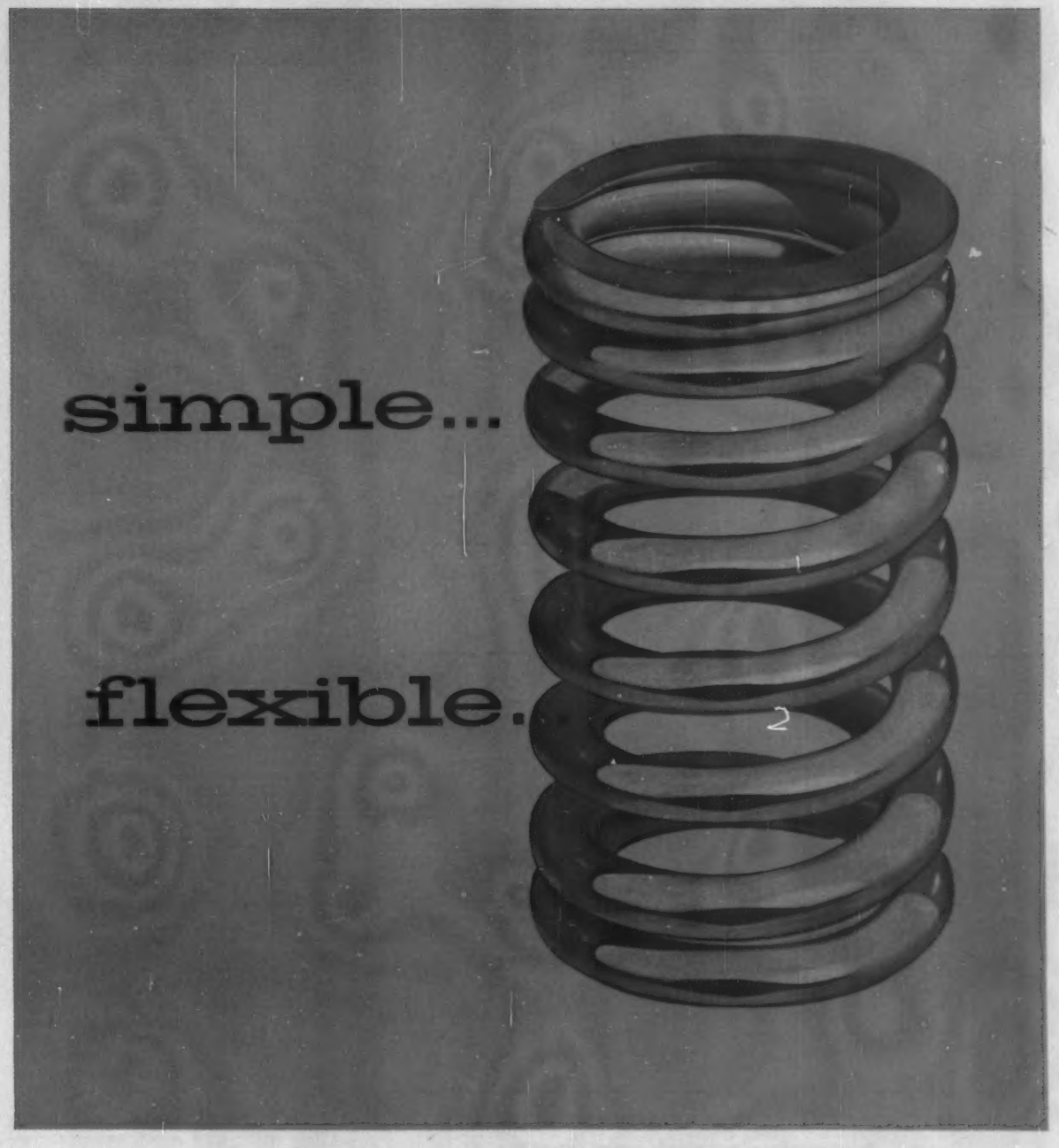
H. P. Wickham has been named manager of The M. W. Kellogg Co.'s newly formed Project Engineering department. The new department combines the Operating division with Project Engineering. Wickham was formerly manager of Operating division, Process dept. He joined Kellogg in 1933 and holds a B.A. degree from Cornell University and a M.S. degree in chemical engineering from the Massachusetts Institute of Technology.

Bunn

Miller

Charles A. Miller of The Texas Company, Houston, and **Charles H. Bunn,** Esso Research and Engineering Co., Linden, N. J., received Certificates of Appreciation at the 11th midyear meeting of the Safety and Fire Protection Committees of the American Petroleum Institute in Denver this month. The API certificates are given in recognition of long, faithful and valued service to the Institute and the oil industry.

Formal presentation of the certificates was made at the traditional dinner meeting May 7, in the Cosmopolitan Hotel. Miller was honored for 18 years of outstanding service as a member of the Central Committee on Accident Prevention,



Refiners around the world are profitably using simple, flexible HOUDRIFORMING to obtain maximum yields of high octane gasoline and aromatics.

The ISO-PLUS Process combines HOUDRIFORMING with either aromatics extraction or with thermal reforming to produce super-fuels beyond the reach of single-pass catalytic reforming. For more than a year ISO-PLUS HOUDRIFORMING has been in commercial operation.

With either process, the superior activity and stability of Houdry Type 3-D Platinum Catalyst lowers catalyst cost per barrel throughput.

Investigate the advantages HOUDRIFORMING, ISO-PLUS HOUDRIFORMING, and Houdry Platinum Catalyst may have for you.

* HOUDRY PROCESSES

*Houdry means Progress . . . through Catalysis

HOUDRY PROCESS CORPORATION, 1528 WALNUT STREET, PHILADELPHIA 2, PA.

For more data on advertised products, use Readers' Service Cards, last page.

INSTALLING LIQUID LEVEL GAGES

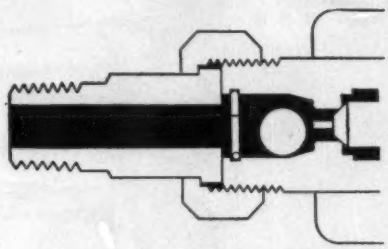
Penberthy "FLOATING SHANK"

lines up off-center holes

Center-to-center variations of vessel tappings or gage assembly can cause costly, inaccurate mounting.

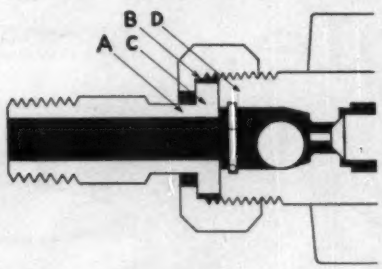
STANDARD SHANK

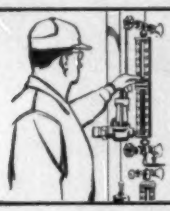
Minimum tolerance between union nut, nipple, and nipple flange prevents *any* corrective movement to compensate for inaccurate tapping. Gage and valve assemblies must either be "force-fitted" or vessel retapped.



FLOATING SHANK

Recessed neck (a) plus wide union opening (b) permit 3/16" movement of flange (c) in ANY direction. Together, "floating shanks" on top and bottom gage valves compensate for off-center tapping errors as high as 3/8". Machined flange (c) assures TIGHT metal-to-metal union with valve body (d).





...eliminates mounting strains

By permitting freedom of movement up to 3/8" in ANY direction, Penberthy "floating shank" principle protects against mounting stresses . . . allows gage and valve assemblies to seek TRUE center-to-center position between inaccurately tapped holes.

AN EXCLUSIVE EXTRA AT NO EXTRA COST

- cuts installation time and replacement costs by 50%
- provides true gage and valve alignment on incorrectly tapped vessels
- eliminates "force-fitting" and subsequent strains on gage and valve assemblies
- prevents possible damage to entire installation
- reduces unnecessary glass breakage due to gage distortion

WRITE for Catalog 36 showing complete line of liquid level gages and valves, Standard or special assemblies available through local suppliers or direct.

PENBERTHY MANUFACTURING COMPANY *Division of Buffalo-Eclipse Corporation*
1242 Holden Avenue Detroit 2, Michigan

Everywhere... you're seeing more
PRODUCTS BY PENBERTHY

EJECTORS
INJECTORS
CYCLING JET PUMPS
LIQUID LEVEL GAGES
GAGE VALVES
SUMP PUMPS

Men in the Industry . . .

and for work in the development of a first aid training and safety guide.

Bunn was cited for 23 years of outstanding service in the interest of fire protection. He too is credited with outstanding contributions to the preparation of national fire codes, and fire protection manuals.

Loyd Thompson has been promoted to chief maintenance engineer in Continental Oil Co.'s headquarters Manufacturing department, Ponca City, Okla. Formerly general maintenance engineer, he will succeed **J. O. Thoen**, who has retired.

Thompson

Thompson joined Conoco at Ponca City in 1937 and later served in key positions at the company's refineries at Wichita Falls, Texas, Lake Charles, La., and Denver, Colo., before returning to Ponca City in 1949. He was assistant refinery superintendent there before his promotion to general maintenance engineer in the headquarters Manufacturing department in 1957. He has a B.S. degree in mechanical engineering from Oklahoma State College.

Victor T. Mavity, Jr. has joined the Ethyl Corp. research laboratories in Detroit as a technical analyst-writer in the Information Services group. He was formerly with Ashland Oil and Refining Co., Lago Oil and Transport Co., and Esso Standard Oil Co. He holds a B.S. degree in chemical engineering from Purdue University.

Dr. Raymond Wynkoop has joined Sun Oil Co.'s Research and Development division as assistant director, petrochemicals.

Dr. Wynkoop

During the past two years Dr. Wynkoop had been assistant to the president of Houdry Process Corp. and manager of sales for Catalytic Construction Co. Earlier he had been a senior project engineer with National Distillers and Chemical Corp. Before that he was with Standard Oil Co. (Ind.) as a chemical engineer.

Dr. Wynkoop graduated from Worcester Polytechnic Institute with a B.S. degree in chemical engineering. He received his Ph.D. degree in 1948 from Princeton University.

Dr. Roger W. Richardson has been appointed manager of the office of refinery liaison in Esso Research and Engineering Co. He had been associate manager of the unit and has been with the company since 1933. He came to Linden three years ago from Baton Rouge, La., where he had been associate manager of the affiliated Esso Research Labs for seven years. Be-

Carbon Monoxide Boiler at Sun Oil Company's Toledo refinery.

3 B&W Carbon Monoxide Boilers Save Fuel For Sun Oil

Sun Oil Company has three B&W Carbon Monoxide Boilers in its refineries at Toledo, Ohio, and Marcus Hook, Pa. All are used with Houdriflow cracking units. The first boiler went on stream at Toledo four years ago. The second, at Toledo, and its twin at Marcus Hook, are of the oxycatalyst type.

The three B&W "CO" Boilers are effecting substantial fuel economies at both refineries.

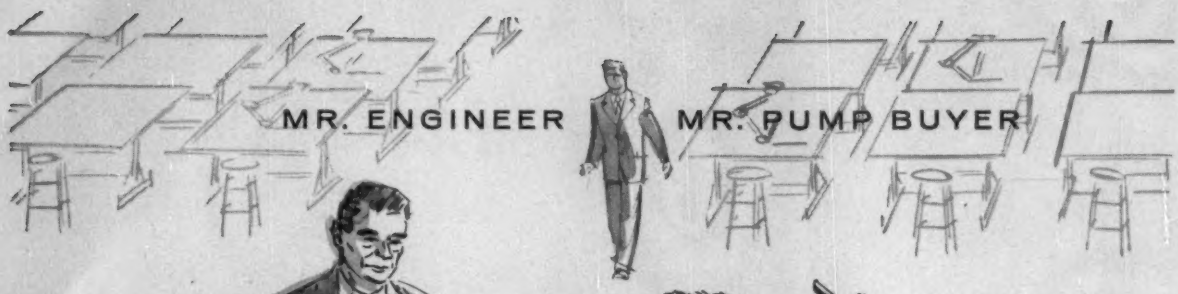
Cracking units at Sun Oil, like others using B&W "CO" Boilers, are completly independent of outside steam and energy sources at all times. Whether or not the cracking unit is operating, steam is always available.

Extended, sustained service has proved the reliability, efficiency, and economy of B&W "CO" Boilers in refineries throughout the nation. They are flexible in design and arrangement to meet varying refinery conditions. B&W engineers can show you how a "CO" Boiler can serve your refinery, regardless of size, steam pressure and temperature requirements. Write for Bulletin G-87. The Babcock & Wilcox Company, Boiler Division, 161 East 42nd Street, New York 17, N. Y.

G-824 CO

BABCOCK & WILCOX

BOILER DIVISION



We've reserved a copy for you

PEERLESS PUMP DIVISION, FOOD MACHINERY AND CHEMICAL CORPORATION
301 West Avenue 26, Los Angeles 31, California

Please send ___ copies of:
☐ Bulletin No. EM-79, MECHANICAL CONSIDERATIONS IN PUMP DESIGN
☐ Bulletin No. B-1608, TYPE DL-DM CHEMICAL PROCESS PUMPS

NAME_____

COMPANY_____

ADDRESS_____

CITY_____ ZONE____ STATE_____

PETR

Putting Ideas to Work

FOOD MACHINERY AND CHEMICAL CORPORATION
Peerless Pump Division
Plants: LOS ANGELES 31, CALIFORNIA and INDIANAPOLIS 8, INDIANA

RESUME OF ORIGINAL RESEARCH ON PUMP RADIAL LOADS AND STRESSES

Describing the cause, effect, and cure of radial thrust forces on pump impellers, bearings, wear rings, seals, stuffing boxes and the shaft itself, the booklet "MECHANICAL CONSIDERATIONS IN PUMP DESIGN" covers the basic types of process pumps, and discusses the load effects on each. Eight pages, profusely illustrated, this informative reference booklet is now available to engineers and pump buyers. For your copy, send coupon today.

PEERLESS PUMPS

Men in the Industry . . .

fore that he was an assistant director of the Louisiana labs. His work at Baton Rouge involved several major fields, including lubricating oils, refining processes and development of petrochemicals. His current assignment is his second in Linden. The refinery liaison man spent 1937-40 here heading work on lubricating oil research. At the start of the war he went back to Baton Rouge in connection with wartime projects on the development of synthetic rubbers.

Dr. Richardson has a Ph.D. degree in chemical engineering from Iowa State College, and his undergraduate work was done at Louisiana State University in Baton Rouge.

John W. Sheehan has been named superintendent of Shell Oil Co.'s Norco, La., refinery. He succeeds **R. S. Douglass, Jr.**, who has been appointed manager of the company's refinery at Martinez, Cal.

Sheehan

Sheehan, formerly chief technologist at Shell's Wood River, Ill., refinery, received his B.S. and M.S. degrees in chemical engineering from Texas Tech and a Ph.D. degree from the University of Texas. He joined Shell in 1947 as a senior technologist at Houston and in 1954 was assigned to the technological department in New York. Two years later he was appointed chief technologist at the Wood River refinery.

P. C. Spencer, president of Sinclair Oil Corp., since 1949, has been elected chairman of the board and chairman of the Executive Committee. He will continue as Sinclair's chief executive officer.

Spencer

M. L. Gosney, after serving Sinclair for more than 41 years, is retiring as Chairman of the Board and Chairman of the Executive Committee. **E. L. Steiniger,** formerly executive vice president-Operations, has been elected president to succeed Spencer.

Gosney was born in Paris, Mo. and attended Central College at Fayette, Mo. He joined Sinclair in 1916 and was named treasurer at Chicago in 1917.

In 1925, Gosney was named assistant treasurer of Sinclair, holding this position until 1940 when he was elected treasurer. He was elected vice president in 1941, and in 1942, was made a director. He was elected executive vice president in 1949 and in May 1955, was elected chairman of the board.

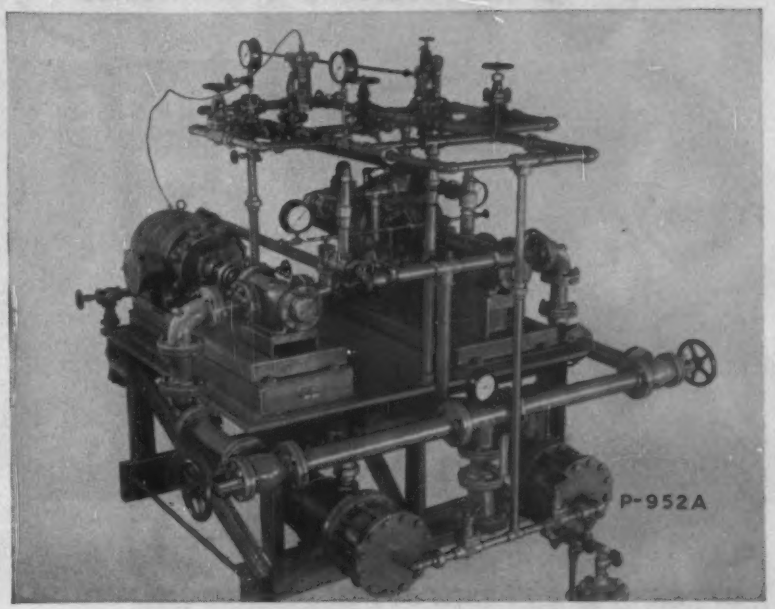
Spencer graduated from the University of Nebraska in 1916.

He joined Sinclair in 1934. He succeeded H. F. Sinclair as president in 1949.

Steiniger attended Pace College and New York University. He joined Sinclair in 1925 where he worked in the company's headquarters until 1928. He then was transferred to Venezuela where he spent

COMPLETE RANGE OF SIZES AND MODELS IN BOTH MEDIUM AND HIGH PRESSURE TYPES

MORE COMPACT THAN EVER..



P-952A Steam Turbine and Electric Motor drive gives flexibility in this compact Model P-ES2H size No. 25 unit.

NATIONAL AIROIL

FUEL OIL PUMPING AND HEATING UNITS

NATIONAL AIROIL Fuel Oil Pumping and Heating Units are specially designed to prepare, for combustion, all grades of fuel oil including No. 6 or Bunker "C" Oil and residuums. They will draw fuel oil from above ground or underground tanks, preheat it to proper constant temperature and deliver it to Oil Burners at an even pressure, best suited for the burners. Our Fuel Oil Pumping and Heating Units are the result of years of experience. They come completely equipped ready for steam, exhaust, condensate, oil suction, oil return, and electrical connections. All valves, regulators, etc., are readily accessible. The piping arrangement is easily understood. These compact, space-saving units are available in a range of sizes and models in both Medium and High Pressure types. For complete details, write for our Bulletin 40 — very interesting and informative.

OIL BURNERS and GAS BURNERS for industrial power, process and heating purposes
STEAM ATOMIZING OIL BURNERS
SLUDGE BURNERS, Steam Atomizing
MOTOR-DRIVEN ROTARY OIL BURNERS
MECHANICAL PRESSURE ATOMIZING OIL BURNERS
DUAL STAGE, Combining Steam and Mechanical Atomization
LOW AIR PRESSURE OIL BURNERS
AUTOMATIC OIL BURNERS, for small process furnaces and heating plants
GAS BURNERS
COMBINATION GAS and OIL BURNERS
FUEL OIL PUMPING and HEATING UNITS
FURNACE RELIEF DOORS
AIR INTAKE DOORS
OBSERVATION PORTS
SPECIAL REFRACTORY SHAPES

NATIONAL AIROIL BURNER CO., INC.

Main Office and Factory: 1254 EAST SEDGLEY AVE. PHILADELPHIA 34, PA.
Southwestern Division: 2512 South Boulevard, Houston 6, Texas

For more data on advertised products, use Readers' Service Cards, last page.

LENAPE

Elliptical Manhole

SADDLES or RINGS and FITTINGS

for Every Pressure Vessel Requirement

Lenape elliptical access openings (straight rings or flued and curved saddles) and fittings are produced in sizes ranging from 4" x 6" to 18" x 24".

Available in many materials

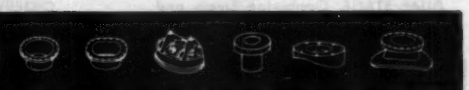
- **Code quality Carbon Steel**
- **304L and 316L Stainless Steel**
- **Everdur 1010 Silicon Bronze**
- **T-1 quenched and tempered steel**
- **also Monel, Nickel and Aluminum**

Low Cost • assured by Lenape's specialized production methods . . . savings which are passed on to you.

For detailed specifications write today for Bulletin 565 or refer to pages 44-48 in Lenape Catalog 10-53.

See our standard line of pressure vessel connections on pages 1128-1129 in the 1958 Chemical Engineering Catalog.

LENAPE PRESSURE VESSEL CONNECTIONS



LENAPE HYDRAULIC PRESSING & FORGING CO.
DEPT. 106 WEST CHESTER, PA.
RED MAN PRODUCTS

Men in the Industry . . .

most of the next 25 years. In 1936, he was elected a director of Venezuelan Petroleum Co. In 1950, he was made president of that company. He was elected vice president of the parent company in 1955 in charge of foreign operations, and was named executive vice president in charge of all operations in 1957.

T. Q. Eliot of Texas Butadiene & Chemical Corp., of Houston has been appointed head of the Process Technical Service department. Eliot, who has been with Texas Butadiene & Chemical since October 1957, will be responsible for process activities and economic evaluation of the corporation's new butadiene and aviation gasoline plant at Channelview, which came on stream early in 1957. He holds B.S. and M.S. degrees from M.I.T., and was formerly process supervisor at Amoco's Brownsville chemical plant, now closed.

Eliot

J. C. Stirton, the Arabian American Oil Co.'s vice president in charge of engineering and construction, retired on May 1.

One of the pioneers in the oil industry in Saudi Arabia, Stirton has been associated with Aramco and, previously, with the Standard Oil Co. of Calif. for 38 years. More than any other individual, he has been responsible for building Aramco's far-ranging physical plant in Saudi Arabia.

With Stirton's retirement, **L. M. Snyder,** previously Aramco's vice president in charge of operations, has assumed the position of vice president in charge of engineering, construction and local sales. **W. R. Cooper** has become general manager for engineering and construction, reporting to Snyder.

Raymond S. Hoffman has been elected to the board of directors of Walter Kidde Engineers Southwest Inc. He has been a member of the Walter Kidde organization seven years. He is manager of Petroleum and Chemical Services. Prior to joining Walter Kiddie Constructors, Inc., he was associated with Esso Standard Oil Co., in the U.S. and abroad for almost 30 years.

Hoffman

Hoffman is a graduate in mechanical engineering from Virginia Polytechnic Institute and is a member of the American Society of Mechanical Engineers and the American Petroleum Institute.

Dr. David T. Mowry has been appointed director of development for Monsanto Chemical Co.'s Research and Engineering division, St. Louis. Mowry suc-

A large diameter steel head takes form on one of Claymont's spinning machines—units that turn out heads up to 19 feet in diameter, in ferrous and non-ferrous metals. Integrated facilities make Claymont a reliable source of quality steel plate and plate products for industry.

by d'Arazien

CLAYMONT SPUN HEADS

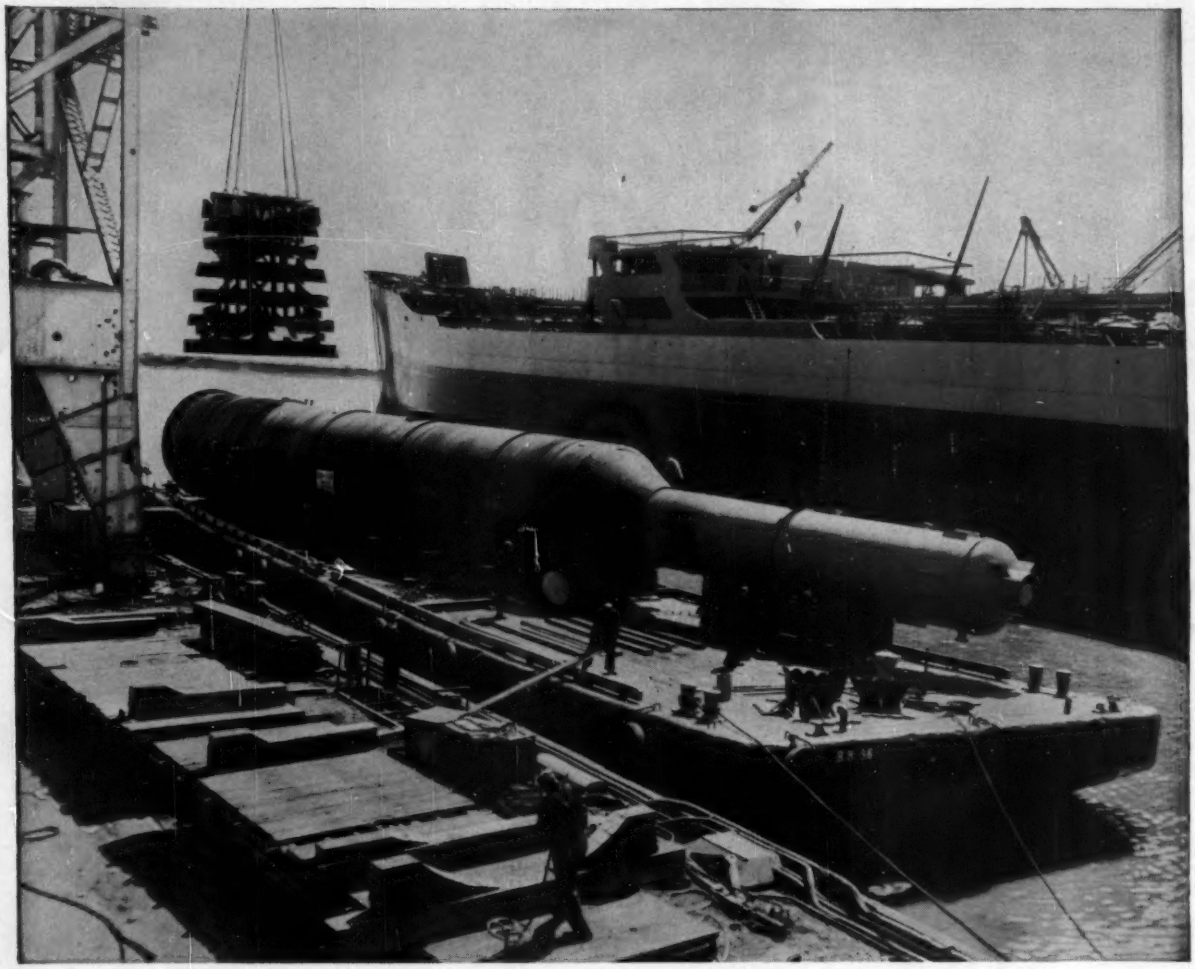
CF&I

CHECK CLAYMONT FOR—Alloy Steel Plates • Carbon Steel Plates • Stainless-Clad Steel Plates High Strength Low Alloy Steel Plates • CF&I Lectro-Clad Nickel Plated Steel Plates • Pressed and Spun Steel Heads • Manhole Fittings and Covers • Fabricated Steel Products Large Diameter Welded Steel Pipe

PRODUCTS OF WICKWIRE SPENCER STEEL DIVISION • THE COLORADO FUEL AND IRON CORPORATION

Plant at Claymont, Delaware • Sales Offices in all Key Cities

5745



standard procedure: VERSATILITY...

The variety of work which Sun Ship's integrated shops produce for use by industries on land and sea brings a matching variety of shipping problems.

Our facilities for tidewater shipment are used to economical advantage on many of the massive structures that go into the making of the nation's petroleum and chemical industries. The barge shipment of tower and shed row baffles, shown above, is a good example.

And of course—when shipment by land is necessary—Sun Ship rigging and routing find the ways and means to handle such items as large-diameter columns by rail and truck.

It's all a part of the versatility which forty years' experience has made part of "standard procedure" in service of its customers.

Our Sales Engineering Department would be glad to use its experience in helping you overcome any problem of construction or shipment that faces you. Write

Sun

SHIPBUILDING & DRY DOCK COMPANY

ON THE DELAWARE (SINCE 1916) **CHESTER, PA.**

Men in the Industry . . .

ceeds **John J. Healy, Jr.**, who has been appointed a member of the company's planning staff.

Mowry joined Monsanto's Central Research laboratory at Dayton, Ohio, in 1941 and became a research group leader there in 1944. He transferred to the company's former Phosphate division in 1952 as manager of chemical development and moved to the Organic Chemicals division's development department in 1954, becoming assistant director of that department in 1957. He holds a B.A. degree from the College of Wooster and M.S. and Ph.D. degrees in chemistry from Ohio State University.

The company's board of directors elected **John L. Gillis** and **T. M. Martin** to the executive committee.

Elected Monsanto vice president was **Irving C. Smith. H. Harold Bible** became a vice president of the company and general manager of the Lion Oil division and **E. J. Cunningham** controller of the company and director of Monsanto's accounting department.

William M. Harp has been promoted to technical assocate in Technical Service division at Humble Oil & Refining Co.'s Baytown refinery. He is responsible for adapting electronic computing equipment to solving engineering, scientific, and economic problems of the various staff groups at the Baytown refinery.

Harp holds a B.S. degree in chemical engineering from Rice Institute and a M.S. degree from M.I.T.

Dr. Robert E. Schilson and **Dr. Robert W. Parsons** have been added as research scientists to The Ohio Oil Co.'s research center near Denver. Each has a Ph.D. degree in chemical engineering and will work in the engineering section of the center.

Dr. Parsons received a B.S. degree in chemical engineering from the University of Idaho. He also studied chemical engineering at the University of Illinois where he received his Ph.D. degree.

Dr. Schilson received his B.S. degree in chemical engineering from the University of Illinois in 1950. He worked three years at the General Electric Co.'s Hanford Atomic Energy works in Richland, Wash., prior to receiving his Ph.D. degree from the University of Minnesota.

P. J. Merkus, manager of Shell Oil Co.'s Wilmington, Calif., refinery, has been named manager of the Wood River, Ill., refinery. He succeeds **H. D. Dale,** who is retiring.

Merkus joined Shell in 1934 as a technologist at St. Louis. He has served at the Norco, La., refinery in charge of the technological department, manager of research and development, and assistant to the vice president of manufacturing in New York. He was appointed manager at Wilmington in 1953.

Robert M. Sachere has been appointed senior process engineer in Blaw-Knox Co.'s Chemical Plants division. He will specialize in design and construction services offered to petroleum and petrochemical industries.

Sachere has eight years experience in project engineering with Arthur G. McKee & Co., Cleveland, and three years in proj-

Lawrence 24" Horizontal Circulating Pump of Nickel Alloy Construction

Cross Section of Lawrence Horizontal Propeller Pump

PROPELLER PUMPS
FOR THE
CHEMICAL and PROCESS INDUSTRIES

Lawrence Propeller or Axial Flow Pumps are widely used to circulate large volumes of liquid or slurry against low heads as in evaporators, crystallizers, etc. This type of pump is particularly well adapted for circulating service because of its simplicity, high efficiency, and low first cost. The flow can be arranged in either direction and the casing turned to any position desired to serve as an elbow. The capacity can be closely regulated by varying the speed—very important in crystallization processes where a uniform velocity must be maintained.

Lawrence Propeller Pumps are made of the metals and alloys best suited for their ability to resist the corrosive and abrasive action of the liquid pumped.

Write for Bulletin 203-7 for summary of acid and chemical pump data.

LAWRENCE PUMPS INC.

371 MARKET STREET, LAWRENCE, MASS.

MAKE ORDINARY EQUIPMENT CORROSION PROOF

KEL-F* LAMINATE offers a way to make any equipment and piping extremely resistant to acids, alkalies, oxidants, and solvents at temperatures up to 350°F—and at reasonable cost.

It is readily cemented over any contour and to any material of construction—metal, wood, concrete, etc. Also, KEL-F, being a thermoplastic resin, seams may be heat-fused into a continuous, chemically impregnable lining which is durable, shatterproof and abrasion resistant.

KEL-F Laminate, Garlock Style No. 9574, is available for installation by certified applicators, trained and equipped to assure best results.

For prompt service, contact one of The Garlock Packing Company's 30 sales offices and warehouses in the U.S. and Canada, or write for Bulletin AD-152.

*Minn. Mining & Mfg. Co. Trademark

United States Gasket

UNITED STATES GASKET COMPANY
Camden 1, New Jersey

Plastics Division of **GARLOCK**

Men in the Industry . . .

ect and process engineering with Wyandotte Chemicals Corp., Wyandotte, Mich. He holds B.S. and M.S. degrees in chemical engineering from the Cooper Union and the Polytechnic Institute of Brooklyn, respectively.

Dr. L. L. Neff has been promoted to section leader at Union Oil Co. of California's Research Center, Brea, Calif., according to an announcement by Mr. John E. Sherborne, Manager of Production Research Division.

Also promoted to section leaders at the Research Center were Earle R. Atkins, Jr., and Dr. Earl Amot.

Dr. Robert E. Wilson has retired as chairman of the board and chief executive officer of Standard Oil Co. (Indiana).

Standard Oil Foundation, Inc. (Indiana), made a $75,000 unrestricted gift to the College of Wooster, Wooster, Ohio, as a testimonial to Dr. Wilson, Wooster graduate and chairman of the college board of trustees. The Foundation gift was announced at a dinner given by the company's board of directors in honor of him. Dr. Wilson has over 35 years of company service. **Frank O. Prior** succeeds him.

L. O. Crockett, a Gulf Oil Corp. vice-president, has been elected president and chief executive officer of Goodrich-Gulf Chemicals, Inc. He has been a director of Goodrich-Gulf since 1952.

Crockett will succeed **W. I. Burt,** who was elected board chairman. He left Gulf Oil to assume his new duties at Goodrich-Gulf's Cleveland headquarters on April 1.

In his 36 years of service with Gulf Oil, Crockett has been a laboratory assistant at the Port Arthur refinery, foreman of a major lubricating oil processing unit, chief chemist and assistant general superintendent for Gulf's Texas refineries, manager of the technical division of the manufacturing department, manager of petrochemical activities, general manager of the chemical department, and vice president, petrochemicals.

Malcom A. Weiss has been appointed head of the production research section process division, Esso Research and Engineering Co. He was formerly assistant head of his division's cracking section.

Weiss joined the company in 1948 and has worked on studies connected with catalytic cracking and projects on jet combustion. He has B.S. and M.S. degrees from Columbia University.

Kermit Roosevelt has joined Gulf Oil Corp. as its director of governmental relations with offices in Washington, D. C. He will maintain liaison between Gulf and governmental agencies of the U. S. and other countries.

Roosevelt, a 1938 Harvard graduate, has been a consultant to various departments of the government, most notably to the Secretary of State concerning Middle Eastern affairs.

J. E. Taylor, former director of Gulf Research & Development Co.'s Automotive Engineering division, has been appointed director, Automotive Research.

Holding a B.S. degree in mechanical engineering from the University of Pittsburgh, Taylor joined Gulf Research in

For more data on advertised products, use Readers' Service Cards, last page.

Refineries get longer life in key spots* with Carpenter Welded Stainless Tubing

By using Carpenter Welded Stainless Tubing, refinery operators can hold down later costs. Lost production due to downtime, and labor costs for retubing of units can be pushed far into the future because of the longer service life that Carpenter Stainless Tubing can give you. And throughout this service, you can count on higher efficiency. Before placing your next tubing order, make a careful investigation of *all* the costs, not just the initial prices. Your Carpenter representative can give you all the information you need. For technical data, Bulletin TD 120 is readily available. Write today. The Carpenter Steel Company, Alloy Tube Division, Union, N. J.

Export Dept.: The Carpenter Steel Co., Port Washington, N.Y.—"CARSTEELCO"

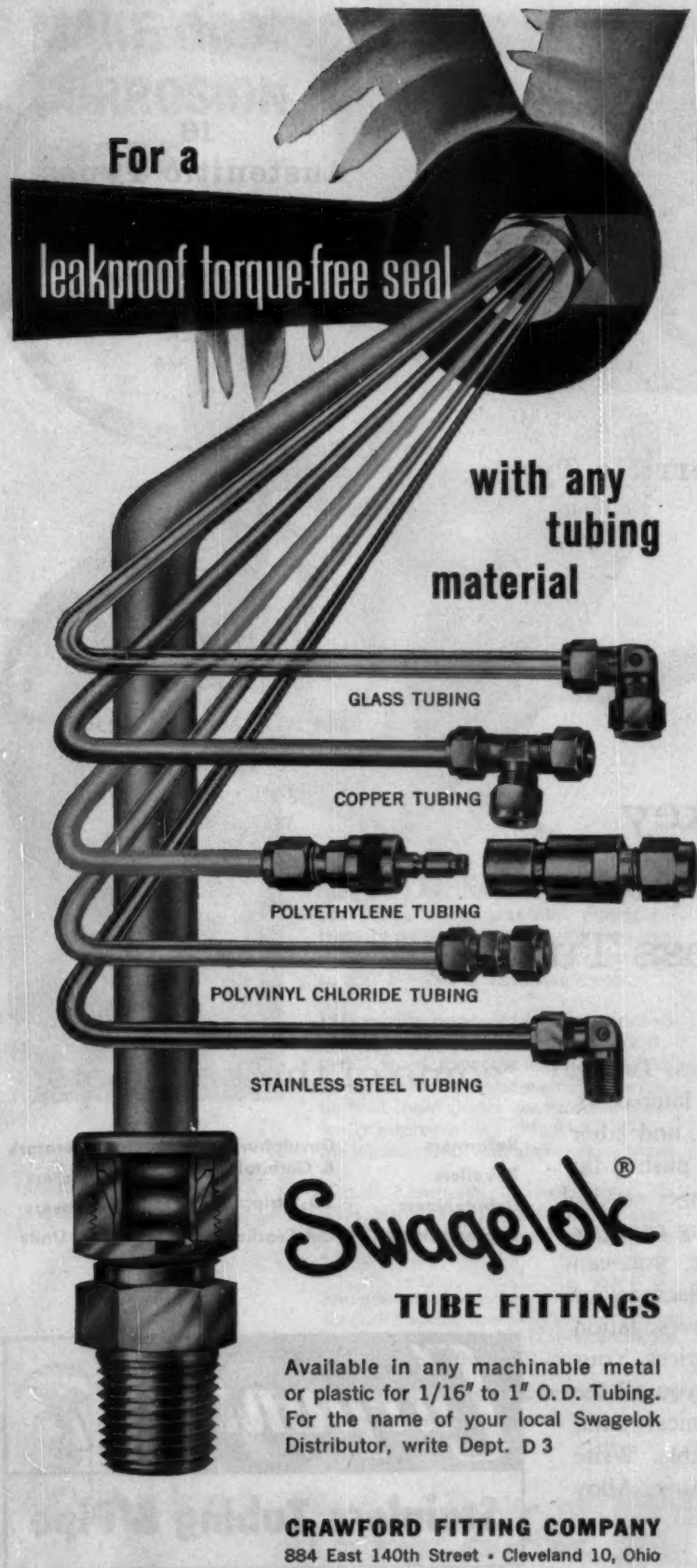
*some of the key spots:

Reformers	Desulphurizers & Gerbitol Units	Regenerators
Reboilers		Air Heaters
Debutanizers	SO_2 Strippers	Condensers
Depropanizers	Cat Crackers	Glycol Units

Carpenter

Stainless Tubing & Pipe

For more data on advertised products, use Readers' Service Cards, last page.


For a
leakproof torque-free seal
with any
tubing
material
GLASS TUBING
COPPER TUBING
POLYETHYLENE TUBING
POLYVINYL CHLORIDE TUBING
STAINLESS STEEL TUBING
Swagelok®
TUBE FITTINGS
Available in any machinable metal or plastic for 1/16" to 1" O.D. Tubing. For the name of your local Swagelok Distributor, write Dept. D 3
CRAWFORD FITTING COMPANY
884 East 140th Street • Cleveland 10, Ohio

Men in the Industry . . .

1934 as an automotive engineer. In 1949, he was transferred to Gulf Oil Corp. as chief product engineer, Gasoline section, Product Development and Product Engineering, Domestic Marketing department. He remained there until 1952, when he was transferred back to GR&DC and appointed director of the newly established Automotive Engineering division.

O. P. Puryear has been named assistant manager, Technical Services division of Texaco's Research and Technical department. He succeeds **R. R. Thurston**, who retired April 1.

Louis E. Endsley, Jr., who succeeds Puryear as assistant manager, Technical Services division, formerly was Director of Technical Services.

Other Research Center changes include **J. Stanley McKeown**, now director of technical services; **Albert D. Togna**, now supervisor of the Field Service department; **August Sellingsloh**, now supervisor of the Products Testing department; **Joseph L. Furtnett**, now assistant supervisor, Analytical department; and **Neil H. Fick**, chemist, Technical Services administration.

J. A. Crowley has been named manager of administrative engineering for The M. W. Kellogg Co. He was formerly manager of systems. Crowley, who attended Newark College, joined the company in 1936.

Dr. Roger W. Richardson has been appointed manager of the office of refinery liaison in Esso Research and Engineering Co., Linden, N. J. He had been associate manager of the unit. Dr. Richardson, who joined Esso in 1933, came to Linden three years ago from Baton Rouge, where he had been associate manager of the affiliated Esso Research labs for seven years. He has a Ph.D. degree in chemical engineering from Iowa State College.

De France Clarke has been appointed manager of the New Projects department of Union Carbide Chemicals Co., Union Carbide Corp. His responsibilities include recognition, appraisal, and development of new project ideas from sources such as Carbide's Market Research department and the research and development programs sponsored by various government agencies and laboratories.

Harry J. Kennedy, Houston senior vice president of Continental Oil Co., was re-elected president of the Western Petroleum Refiners Association last month at the group's 46th annual meeting in San Antonio.

Kennedy has been associated with Conoco since 1919. He became general sales manager in 1930, vice president in 1936 and senior vice president earlier this year.

Re-elected vice presidents of WPRA were **Rex S. Blazer**, Ashland, Ky., Allied Oil Co.; **W. J. Carthaus**, St. Paul, Minn., Great Northern Oil Co.; **Walter Famariss, Jr.**, Hobbs, N. M., Famariss Oil and Refining Co.; **F. L. Martin**, Corpus Christi, Texas, Suntide Refining Co.; and **J. A. Vickers**, Wichita, Kan., The Vickers Petroleum Co.

New WPRA directors elected were **O. C. Johnson**, New York, Socony Mobil Oil Co.; **John F. Lynch**, Tyler, Texas, La

For more data on advertised products, use Readers' Service Cards, last page.

HOW TO SELECT WATER-CONDITIONING EQUIPMENT (NO. 2 OF A SERIES)

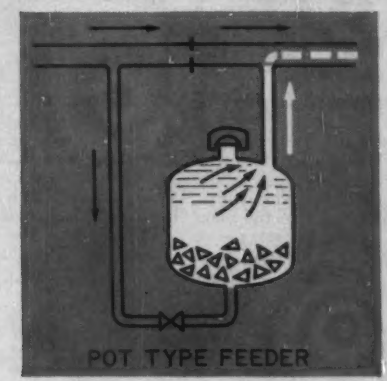
Chemical Feeders

Practically all water-treatment systems include addition of chemicals for one or more purposes: as coagulants to adsorb color, organic matter, oil and turbidity; to raise or lower pH; for lime softening; to inhibit corrosion; to kill bacteria; to adsorb tastes and odors.

The method of feeding the chemicals depends on the kinds used and on the volume, accuracy and proportions required. In general, solution feeders are used for smaller dosages and chemicals which can't be fed dry; dry feeders for large dosages. Here are some of the most-used types of feeders:

Pot type feeders

These are used for slow-dissolving chemicals in crystal or lump form (alums, sal soda, etc.) or special briquets. The chemical is placed in the feeding pot where it is dissolved by by-pass water flowing from the high-pressure side of an orifice to the low-pressure side. Since this flow is proportional to the main flow, the amount of chemical fed is proportional. Variations in amount and solubility of the chemical can, however, affect the feed rate.



Pressure solution feeders

These allow use of lower cost chemicals (aluminum sulfate, soda ash, etc.) than pot type feeders and provide more accurate control. The chemical is dissolved in the open tank. When needed, the solution is charged into the bottom of the pressure tank, and the displaced water, being lighter, flows out the top to waste. A sight glass float shows the level of the chemical solution in the pressure tank. When on the line, the feeder feeds from the bottom.

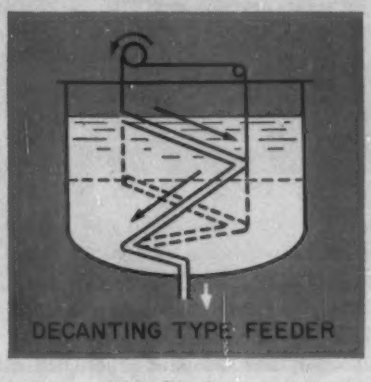
Note that solution feed is into a by-pass circuit instead of directly into the raw water line. This eliminates a long vertical run of undiluted solution which, because of its greater weight over the water in the circuit, could affect proportional feeding accuracy.

Gravity orifice feeders

A solution of known concentration flows through an adjustable orifice under constant head to provide the desired rate. For intermittent feed, a solenoid valve on the orifice discharge line is operated simultaneously with a raw water pump. Low in cost but limited to constant water flow rates and clear solutions that will not clog the orifice.

Decanting type feeders

This type is known as Permutit Electro-Chemical Feeder. A swing draw-off pipe is lowered at a speed that draws off solution at the desired rate. Feeds practically any type of solution or slurry used for water treatment.



For proportional feeding, a water meter operates a timer that starts the feeder motor which lowers the draw-off pipe for a pre-set period. The timer controlling the lowering rate is easily adjustable allowing wide flexibility and accurate control. Rugged construction. Available with mixing propeller and with cover and dust evacuator.

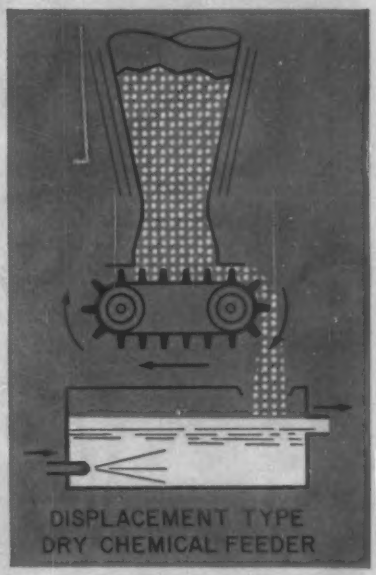
Reciprocating pumps

Pumps with adjustable length of stroke are widely used as feeders . . . generally operated by a meter and timer. Since volumes fed per stroke are uniform, feeding is accurately controlled.

A duplex or double pump feeds one solution to 2 or more points . . . or 2 or more solutions to the same or different points . . . in adjustable proportions.

Dry chemical feeders

A displacement type dry feeder eliminates batch weighing or measuring of dry chemicals and delivers a constant flow of accurately measured amounts of dry chemical (by volume) to a mixing chamber through which water flows at a sufficient rate for good mixing and to prevent settling.



The chemical is discharged from a vibrated hopper onto a moving belt with lugs which "slice" off equal, exact volumes of the dry material. The belt speed is adjustable to deliver from 0 to hundreds of lbs. per hour by simple setting of a stepless speed changer. Adjustable while feeder is running, if required.

The feeder can be designed for constant rate feed or, with a meter and timer, for proportional feeding. Feeds practically any type of non-deliquescent dry powder or granules. Can be equipped with counter to show cumulative amount of chemicals fed.

• • • •

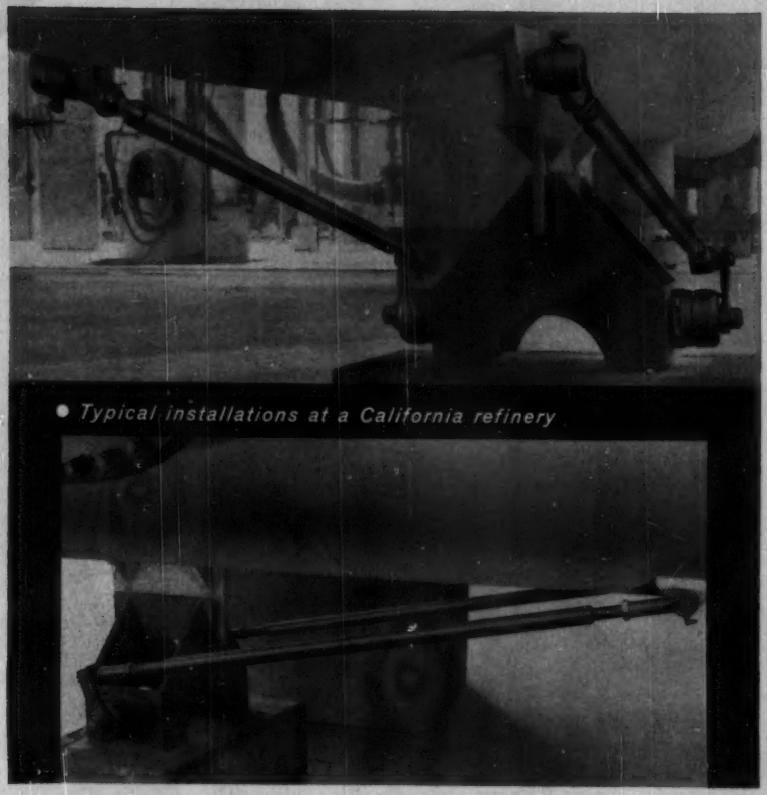
For complete details on feeders or other types of water-conditioning equipment, write: The Permutit Company, Dept. PR-5, 330 West 42nd Street, New York 36, N. Y. or Permutit Company of Canada, Ltd., Toronto 1, Ont.

PERMUTIT®
rhymes with "compute it"
a division of PFAUDLER PERMUTIT INC.
Water Conditioning
Ion Exchange • Industrial Waste Treatment

For more data on advertised products, use Readers' Service Cards, last page.

extend pipe life...

with HOUDAILLE ROTARY SHOCK ABSORBERS



• Typical installations at a California refinery

PIPELINE VIBRATION is a primary cause of constant and costly *pipe fatigue* in refineries and processing plants. Conventional hangers and other supports are not designed to absorb or dampen this vibration. The most practical solution is the location of Houdaille Rotary Shock Absorbers at all "danger points" in the lines. These rugged units are independently mounted, to eliminate damaging vibration and resultant pipe fatigue.

Recommended and used by leading refinery engineers throughout the world.

Exclusive rotary design • Easily installed
Readily serviceable • Sealed against dirt, water, corrosion • Long, trouble-free life

FREE TECHNICAL BULLETIN on Houdaille Rotary Shock Absorbers. Write to...

HOUDAILLE INDUSTRIES, INC.

Please send details of your problem to us.

Houdaille Industries, inc.

BUFFALO HYDRAULICS DIV. • 537 E. Delavan Ave., Buffalo 11, N. Y.

Men in the Industry...

Gloria Oil and Gas Corp.; **W. S. Peeler**, New York, American Oil Co.; **Fred P. Sewell**, Dallas, Delhi-Taylor Oil Corp.; **J. H. Sheehan**, El Dorado, Ark., Lion Oil Co.; **W. G. Tierney**, Wichita, Derby Refining Co.; and **Leo J. Wilmeth**, Amarillo, The Shamrock Oil and Gas Corp.

Re-elected directors were **Robert O. Anderson**, Roswell, N. M., Malco Refineries; **Earl Baldridge**, Fort Worth, Champlin Oil and Refining Co.; **Charles R. Brown**, Tulsa, Tidewater Oil Co.; **W. T. Cravens**, Bartlesville, Okla., Cities Service Oil Co.; **T. E. Fitzgerald**, Tulsa, D-X Sunray Oil Co.; **T. B. Kimball**, New York, Sinclair Refining Co.; **L. E. Kincannon**, Indianapolis, Rock Island Refining Corp.; **J. P. Langfitt**, Chicago, The Pure Oil Co.; **L. L. Leabo**, Houston, Bay Petroleum Corp.; **F. C. Love**, Oklahoma City, Kerr-McGee Oil Industries.

R. E. Luton, Findlay, Ohio, The Ohio Oil Co.; **E. B. McConnell**, Cleveland, Standard Oil Co. (Ohio); **Bruce H. McCully**, Kansas City, Mo., Cooperative Refinery Assn.; **L. W. Robbie**, Texas City, Republic Oil Refining Co.; **R. G. Sanders**, Beaumont, Magnolia Petroleum Co.; **E. M. Stone**, Denver, Empire Petroleum Co.; **C. C. Tate**, Bartlesville, Phillips Petroleum Co.; **J. W. Vaiden**, Tulsa, Skelly Oil Co.; and **Everett F. Wells**, Ashland, Ky., Ashland Oil and Refining Co.

Robert E. Pulver will manage Standard-Vacuum Oil Co.'s new $33.5 million Bataan refinery project in the Phillippines. He also has been elected a director of the newly-formed subsidiary, Standard-Vacuum Refining Corp. (Philippines) which will operate the plant. He began his duties at Manila on January 20, taking charge of pre-construction activities.

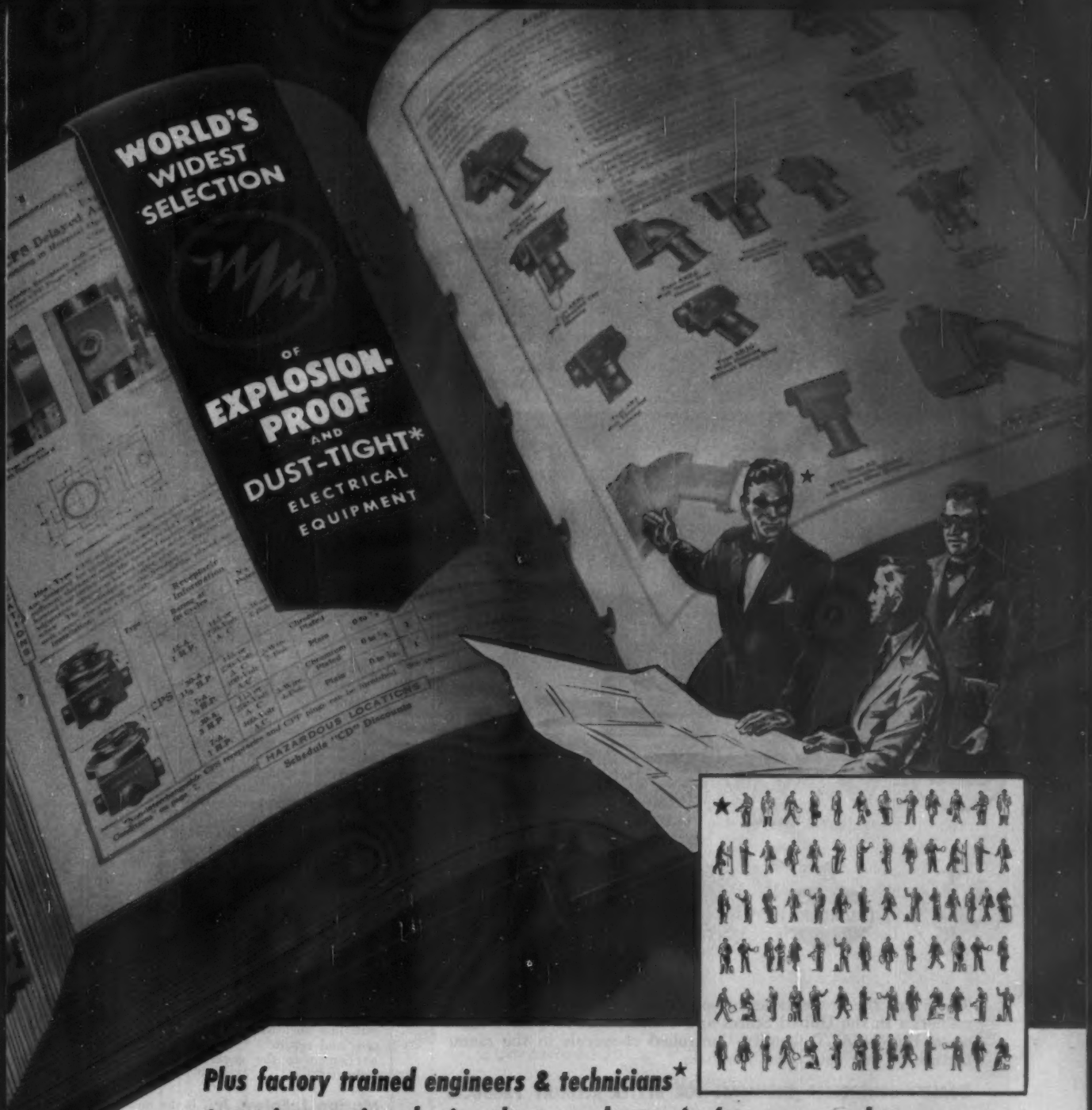
Pulver is a graduate of Purdue University where he received his mechanical engineering degree in 1934. He has had 21 years' experience in the oil industry. Since joining Standard-Vacuum in August 1955 as a supervising engineer in the Refining Coordination division, Pulver has been closely associated with the Bataan refinery project and with the development of plans for other new refineries and refinery components.

William H. Goryl has begun a rotational assignment as assistant director in the design engineering division of Esso Research and Engineering Co. He had been head of the estimating services section of the firm's planning engineering division.

Goryl, who joined the company in 1946, is a mechanical engineer from Stevens Institute of Technology, Hoboken. He has had a number of overseas assignments in connection with start-ups and design work for refineries in France, Belgium, Germany, South Africa, Italy and Venezuela.

Dr. George W. Beste has been appointed general manager of research and development operations at Ethyl Corp.'s manufacturing plants in Baton Rouge, Houston and its new plant nearing completion in Pittsburg, Calif.

Other promotions: **Dr. Paul A. McKim**, who will be assistant general manager of the Research and Development department; **Paul E. Weimer**, who becomes director of chemical research and development; **Russell L. Hudson**, who is appointed



Plus factory trained engineers & technicians to assist you in selecting the types best suited to your needs*

There are more than 17,000 items in the Crouse-Hinds line of Condulet® and floodlighting equipment. Each is designed with some specific advantage or quality that makes it best suited for a particular application.

Of course, no engineer, electrician or contractor with a regular job to do, could possibly keep in mind all the pertinent data and information concerning each of these items. That's why Crouse-Hinds maintains a factory-trained field staff of 80 graduate E.E.'s and technical men.

Their job is to confer with the users of Crouse-Hinds equipment and to point out the reasons why certain Condulet equipment or floodlights are better suited for a particular job than others. With a broad grounding in the details of the National Electrical Code and a trained alertness for spotting explosion hazards in unsuspected places, they make a consulting or factory-engineer's job less onerous.

Their service is prompt and without obligation. Naturally they usually work on jobs of sufficient size to merit top-level attention, but even a small job with a large problem gets the same careful appraisal. If you'd like to talk or correspond with such a specialist, just write, wire or phone.

CROUSE-HINDS COMPANY

*Dust-ignition-proof

Main Office and Factory: Syracuse, N.Y.
Crouse-Hinds Company of Canada, Ltd.: Toronto, Ont.

Offices: Baton Rouge · Birmingham · Boston · Buffalo · Chicago · Cincinnati · Cleveland · Corpus Christi · Dallas · Denver · Detroit · Houston · Indianapolis · Kansas City · Los Angeles · Milwaukee · New Orleans · New York · Philadelphia · Pittsburgh · Portland, Ore. · Salt Lake City · St. Louis · St. Paul · San Francisco · Seattle · Tulsa · Washington
RESIDENT REPRESENTATIVES: Albany · Atlanta · Baltimore · Charlotte · Chattanooga · Jacksonville · Reading, Pa. · Richmond, Va. · Shreveport

Men in the Industry . . .

assistant director of research and development services; and N. G. Adams, who becomes supervisor of the instrument group in research and development services.

Clarence J. Morrissey has joined Standard Oil Co. (Indiana) as a patent searcher in the development and patent department after 10 years of industrial research experience in the fields of organic chemistry, plastics, and petrochemicals. He attended Loyala University of Chicago and received B.S. and M.S. degrees from Northwestern University.

B. R. Putnam, Jr., has been appointed manager of the petrochemicals department of American Cyanamid Co.'s Organic Chemicals division.

The department's major product is acrylonitrile which is used in making synthetic fibers, rubbers and plastics.

A graduate of Princeton University, Putnam has been with Cyanamid since 1947 when he joined the company as a chemical engineer. He joined Cyanamid's market research department in 1949 and was named manager in 1952. Since 1955 he has been manager of market development for the company.

Putnam is a member of the American Chemical Society and the Chemical Market Research Association. In his new position he will make his headquarters in New York City.

Lawrence Lowy, formerly eastern regional manager of petroleum sales for Proportioneers, Inc., has formed a new firm of engineering consultants, John-Lawrence Associates to serve the petroleum and petrochemical industries.

The organization will handle products at both the manufacturing and marketing level. In addition to studies of the economics of any installation—existing or proposed—John-Lawrence Associates will also handle the design and engineering of new and remodeled facilities. The firm is located at 36 West 40th St., New York 18, N. Y.

Frank R. Fisher and **C. J. Francisco** have been elected vice presidents of Sinclair Research Laboratories, Inc. Fisher will be in charge of operations while Francisco will be concerned with patent and licensing matters.

Fisher joined the Research and Development department at East Chicago, Ind. in June, 1940. He was formerly corporate secretary of Sinclair Research, and is a graduate of Colorado School of Mines.

Francisco joined the Research and Development department in 1941. A graduate of Columbia University, Francisco, currently technical manager at Harvey, Ill., will be transferred to New York.

Gerald B. Shea, chief of the Bureau of Mines' Region II Division of Petroleum Technology and superintendent of the bureau's Pacific Petroleum Experiment station at San Francisco, has received the Department of the Interior's highest honor, its Distinguished Service Award and Gold Medal.

Shea, a 1921 graduate of the Michigan College of Mines, joined the bureau at San Francisco in 1927. Except for a detail to the bureau's Washington headquarters in 1929-33 and another to General MacArthur's headquarters in Tokyo in 1946-47, he has been stationed at San Francisco ever since.

His first assignments involved engineering analyses of safety problems of the petroleum industry. He was able to enlist industry cooperation, and in 1929 the bureau published his paper, "Safety at Natural Gasoline Plants," which continues to be used extensively in the industry.

Returning to San Francisco after being assistant to the acting chief of the bureau's petroleum division in 1933, Shea collaborated with the late H. C. Miller in developing a chemical method for removing mud sheaths that were hampering oil output. The Shea-Miller method proved effective and resulted in issuance of a patent assigned to the government for use by industry.

Marion J. Epley, Jr., is the new assistant to the chairman of The Texas Co.'s board of directors. Epley has been general attorney for Texaco in New York since 1953.

A graduate of Tulane University Law School, he practiced law in New Orleans until 1947, when he joined The Texas Co.'s Legal department.

He was named the company's chief attorney for Louisiana in 1948, and three years later was promoted to general attorney in New Orleans. In 1952 Epley was transferred to New York.

L. G. (Gayle) Rodgers, general manager of the gas division of Sunray Mid-Continent Oil Co., has returned to his Sunray general office duties in Tulsa, following a year's service with the Oil and

PENNSALT CHEMICALS

ARE KNOWN BY THE GOOD COMPANY THEY KEEP

Carter · CONOCO · MARATHON · Mobilgas · Phillips 66 · SHELL · SINCLAIR OILS · STANDARD · STANDARD OIL COMPANY OF CALIFORNIA · TEXACO · UTOCO

These are the trademarks of some of the many widely-known refineries in the United States and Canada who long have relied upon PENNSALT Quality-Controlled chemicals in the manufacture of fine petroleum products.

QUALITY-CONTROLLED CHEMICALS FOR BETTER REFINERY PRODUCTS

Pennsalt CAUSTIC SODA • Pennsalt LIQUID CHLORINE
Pennsalt ANHYDROUS AMMONIA
Pennsalt ANHYDROUS HYDROFLUORIC ACID

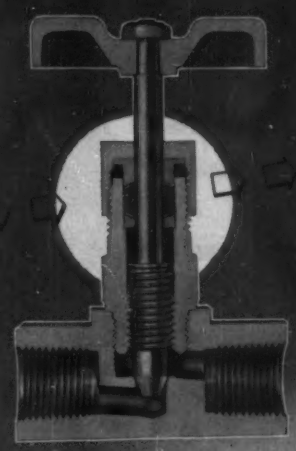
PENNSALT OF WASHINGTON DIVISION
PENNSALT CHEMICALS CORPORATION
TACOMA, WASHINGTON

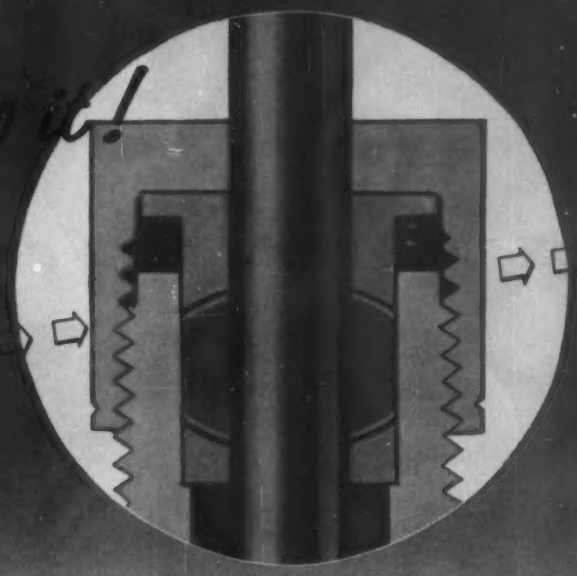
OFFICES AND TELEPHONES

Tacoma, Wash.—MArket 7-9101
Berkeley, Calif.—AShberry 3-2537
Philadelphia, Pa.—LOcust 4-4700
Portland, Ore.—CApitol 8-7655
Los Angeles, Calif.—LUdlow 7-6244
Vancouver, B.C.—PAcific 7578

Pennsalt Chemicals
ESTABLISHED 1850

Marsh has it!





Available in MARSH

416 Stainless Steel Needle Throttling Valves

- Body and stem guide machined from bar stainless steel stock
- Valve Stem hardened stainless
- Fine stem threads for extra strength and precision throttling
- Deeper inlet and outlet chambers
- Bodies made in accordance with MSS regulations
- Packing "Marpak" system incorporating "Teflon" as described opposite

The Marpak Packing System —*now with fabulous* "TEFLON" PACKING

An outstanding feature of the Marsh Needle Valve has been the Marpak Packing System. This unique method of obtaining a tight, but non-binding seal is one of the important reasons for the ability of Marsh Valves to give precision regulation at any pressure up to 10,000 psi.

Now the Marpak system has been made still better by the use of today's miracle material—"Teflon." You probably know of the almost incredible toughness, resilience and non-adhesive properties of Teflon—properties that are unimpaired by the most powerful of solvents, acids, or alkalies, even at temperatures up to 500° F.! As a result of incorporating "Teflon" packing, Marsh Stainless Steel Needle Valves are now

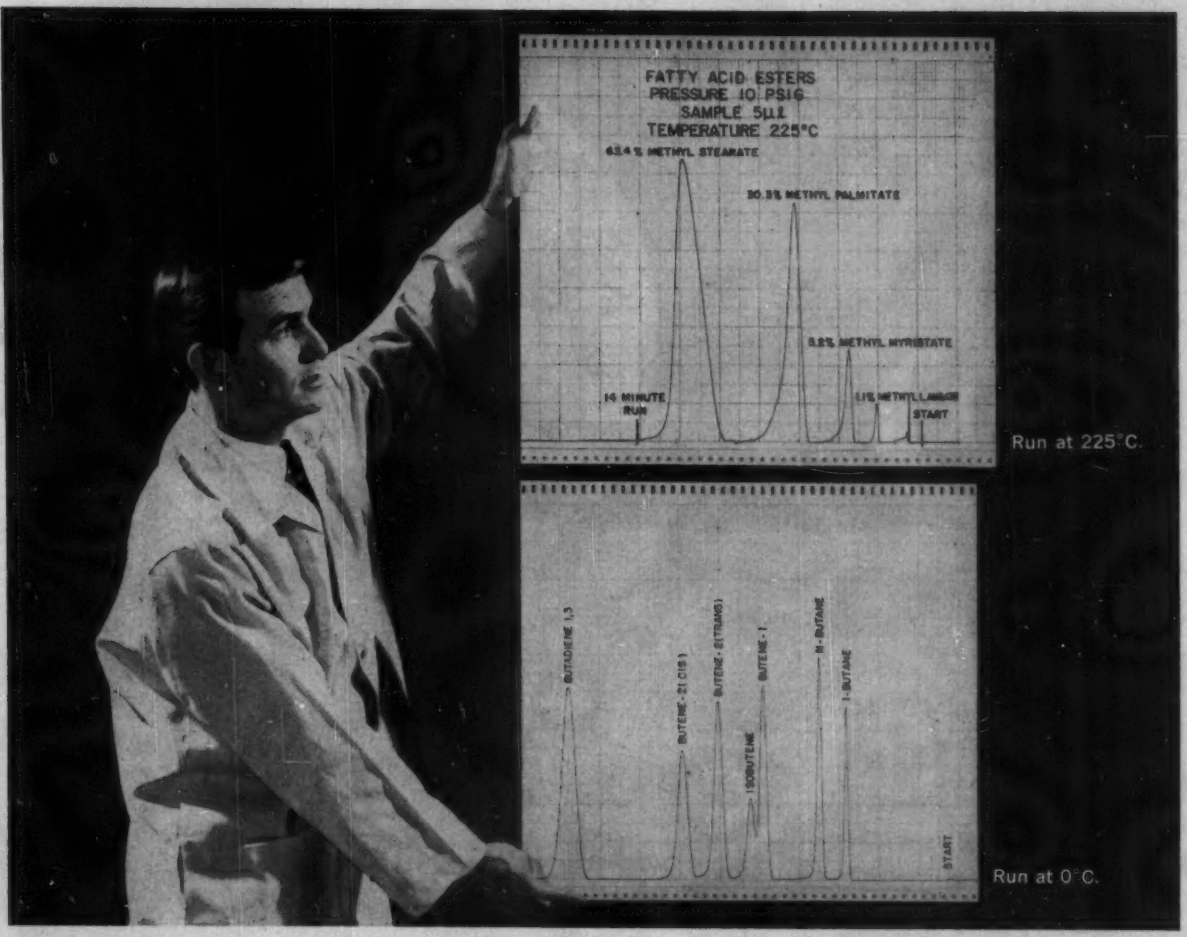
Guaranteed for any pressure up to 10,000 psi at any temperature up to 500° F.

In other makes of valves permissable temperature *decreases* as pressure *increases*—but not with Marsh.

Teflon packing is one more addition to the list of features that are combined only in Marsh Stainless Steel Needle Throttling Valves. Note the list opposite...ask for bulletin.

MARSH INSTRUMENT CO. *Sales Affiliate of Jas. P. Marsh Corp.*, **Dept. L Skokie, Ill.**
Marsh Instrument and Valve Co. (Canada) Ltd., 8407 103rd St., Edmonton, Alberta
Houston Branch Plant: 1121 Rothwell St., Sect. 15, Houston, Texas

For more data on advertised products, use Readers' Service Cards, last page.



Extended Column Temperature Range for Gas Chromatography:

NEW PERKIN-ELMER Model 154-C VAPOR FRACTOMETER INCREASES THE ANALYTICAL REACH OF ANY LABORATORY

An unprecedented column temperature range – from −78.5°C to 300°C–permits the Perkin-Elmer Model 154-C Vapor Fractometer to make clean separations of mixtures ranging from inert gases and light hydrocarbons to heavy oils, greases – and even solids. With its complete line of accessories, the Model 154-C gives you the broadest quantitative capability of any single-stage chromatographic instrument on the market.

HERE'S WHAT THAT MEANS TO YOU:

Advanced design enables the Model 154-C to shoulder a bigger portion of your analysis work. For example, three new refrigerated columns for the 154-C let you handle rare gas studies, trace analyses of light gases, and checks of many industrial hydrocarbon mixes. On the other end of the scale, high temperature columns separate liquids – and solids – boiling up to 400°C. The *high sensitivity* thermistor detector measures traces and major components with equal accuracy. Once set, column temperature varies only one-tenth of a degree C. Automatic control of peak attenuations keeps major components on scale–permits unattended operation. A copper oxide combustor reduces complex hydrocarbons to easily-measured CO_2 and H_2O – enhances detector sensitivity and prevents fouling of detectors and vent lines.

Find out how the Model 154-C can enlarge the scope of *your* research and development work. Write us at 880 Main Avenue, Norwalk, Conn.

APPLICATIONS OF THE 154-C

- Analyses of H_2, O_2, N_2, CO, CO_2, NO, N_2O
- C_1-C_{16} hydrocarbons
- Natural gas
- Liquefied petroleum gas
- Cylinder gases
- Combustion products
- Refrigerants
- Chlorinated hydrocarbons
- Aromatic hydrocarbons
- Alcohols, aldehydes, ethers, esters, amines, amides, fatty acids
- Nitroparaffins
- Air pollution studies
- Water in organic solvents
- Plastic raw material control
- Essential oils
- Paints & lacquer thinners
- Food odors & flavors
- Metabolic product analysis

INSTRUMENT DIVISION
Perkin-Elmer *Corporation*
NORWALK, CONNECTICUT

For more data on advertised products, use Readers' Service Cards, last page.

Men in the Industry . . .

Gas division of the U. S. Department of the Interior, Washington, D. C.

Rogers served on the Interior department staff as an oil industry volunteer during a leave-of-absence from his Sunray assignment. In government duty he served as an industry commodity analyst and as a refinery technologist.

Milton Winyall, chemical engineer for the Davison Chemical Co., Division of W. R. Grace & Co., has been named recipient of the **Marlin G. Geiger** award for individual accomplishment by employees. Winyall was chosen for his contribution to process improvement in petroleum catalysts.

The award, which is $1,000 and a scroll, is named for Geiger, executive vice president in charge of Grace's chemical group. He and **W. E. McGuirk, Jr.,** president of the Davison division, made the presentation.

Basis of the award is stated as "outstanding and effective contributions to the development of all phases of the management skill or technique in operations, research, marketing, accounting, purchasing, traffic or human relations within the Davison organization." Winyall is the second recipient; previously it had been conferred on **James W. Elston.**

Winyall, a graduate of Lawrence Institute of Technology, came to Davison in 1950.

David P. Hankins, manager of Pure Oil Co.'s Heath, Ohio refinery since 1955, has been appointed to the newly created position of manager of the company's Lemont, Ill., refinery. **Dale G. Miller,** general superintendent at Heath, has been named general superintendent at Lemont, replacing **J. M. Lawson.**

Willard G. Dailey is the new manager at Heath, coming there from the Toledo refinery, where he has been general superintendent.

Harry Hook and **Jack N West** have been promoted to general superintendents at the Health and Toledo refineries, respectively. Both men were formerly superintendents of operations.

J. Q. Foster, F. C. Stehling and **Lowell Westerman** have joined Research and Development division at Humble Oil & Refining Co.'s Baytown refinery. Foster has just received his M.S. degree in chemical engineering at Texas University; Stehling and Westerman hold Ph.D. degrees in chemistry from Texas and Tulane Universities, respectively.

Raymond F. Maldoon has been named patent advisor at the Whiting Research Laboratories, Standard Oil Co. (Indiana).

Maldoon graduated from Kansas State College and joined the company in 1947. He most recently served as a technologist in the Development and Patent department in Chicago.

Dr. Frederick A. Matsen, University of Texas chemical physicist, has received a $40,000 American Chemical Society award in recognition of his past achievements in basic chemical research.

ACS's Petroleum Research Fund advisory board in Washington selected Dr. Matsen.

Dr. Matsen received the ACS-PRF award

Note rugged branch construction on this massive oil header fabricated with a length of pipe and five 30 x 12 and two 30 x 30 weldolets.

BIG PIPE BIG MONEY to be SAVED by using 30 x 30 BONNEY WELDOLETS

Closer manifolding, ease and speed of field fabrication without header distortion, lower purchase and welding costs are just a few of the profit benefits of header fabrication with Bonney Weldolets. Today there is particular need for reducing costs. Bonney Forge can provide this opportunity for cutting costs in your company. Write, phone or wire for details.

BONNEY

WELDOLETS®
THREDOLETS®
SOCKOLETS®
ELBOLETS®
BRAZOLETS®

CARBON STEEL
STAINLESS
ALLOY
for all services

BONNEY FORGE AND TOOL WORKS

Dept. M

ALLENTOWN, PENNSYLVANIA

For more data on advertised products, use Readers' Service Cards, last page.

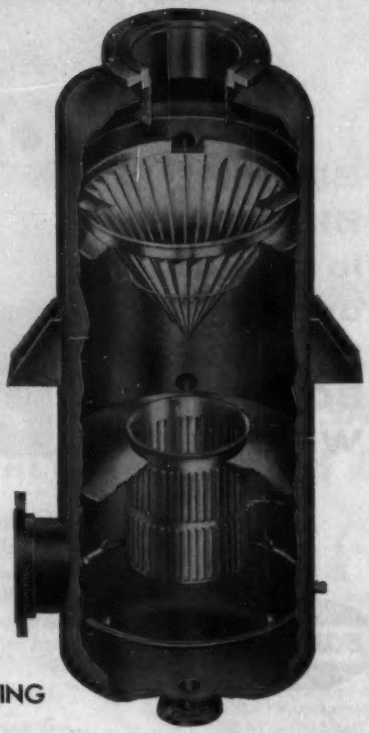
STOP
Entrainment
Losses

IN
Petroleum Refining
Gas Processing & Transmission
Chemical Processing
Food Packing & Canning
Pharmaceutical Manufacturing
Power Plants • Steam Generation
Steel Mills • Sintering Plants
Incinerators • Garbage Disposal
WITH

Centrifix®
WD SCRUBBER

GUARANTEED
TO REMOVE
99.5% OR MORE
of ALL solid or
liquid entrainment
in gas or vapor

- regardless of entrainment density, chemical characteristics or size (even 1 micron or smaller).
- regardless of pressure, temperature or flow rate of the flowing medium.



LOW COST • SAVES SPACE
NO MOVING PARTS
NO MAINTENANCE NEEDED
EASY TO INSTALL
SELF-CLEANING • NON-CLOGGING
MINIMUM PRESSURE DROP

AA-7270

Write today for
Bulletin 500.

FOR THE FINEST IN
PURIFYING EQUIPMENT
FOR STEAM-VAPOR-GAS-AIR

Centrifix®
CORPORATION
3608 PAYNE AVENUE
CLEVELAND 14, OHIO

All Centrifix equipment is protected by U. S. Letters Patent & Patents Pending

Men in the Industry . . .

to help further his fundamental research on the theory of organic molecules. The award, given to advance basic research "of potential value in the petroleum field," will provide funds for two years' research, from Sept. 1, 1958, to August 31, 1960.

"These funds may be used by Dr. Matsen in any manner he sees fit to advance the research for which the award is made," Alden Emery, ACS executive secretary, said.

In his research on the theory of molecules, Dr. Matsen attempts to predict "from the first principles what the properties of molecules will be." His approach is mathematical, rather than experimental.

Dr. Matsen and his graduate assistants make constant use of high speed electronic computers in compiling theoretical chemical data. With this information, chemists in the petroleum industry will have a basis for prediction of reactions in various chemical refining processes. Such data should give "clues to the engineers trying to design better processes," Dr. Matsen noted.

Dr. Matsen, a professor of both theoretical chemistry and physics, joined the University of Texas faculty 16 years ago, after receiving a Ph.D. degree from Princeton University in 1941.

W. R. Stephens, elected president of Arkansas Louisiana Gas Co.

Stephens has been chairman of the board of Arkansas Louisiana since Jan. 1, 1957, and will continue in that position, also.

D. W. Weir, of Shreveport, will be executive vice-president and was elected to the board of directors. **Lindsey Hatchett**, was elected a new vice-president of the company. He previously has served as a vice-president and Hatchett has worked on special assignments for ALG for several years.

Alvah E. Esser has retired from Socony Mobil Oil Co., Inc., where he has been manager of the engineering department since 1938.

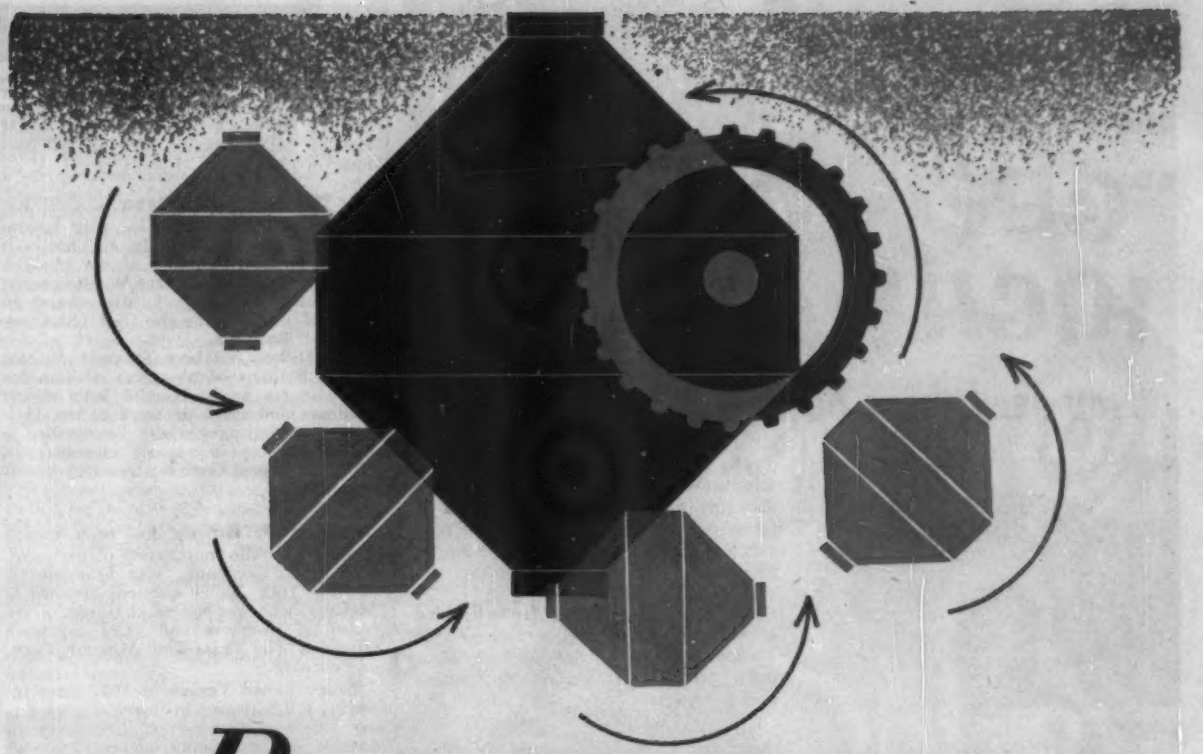
He joined the company in 1915 as a fireman at the Socony's Long Island refinery. He later held positions as refinery foreman, assistant superintendent, and in 1923 was transferred to the company's Pratt Works refinery at Brooklyn as superintendent, and in 1928 was made superintendent of the Atlas Works refinery at Buffalo. In 1932 he returned to Brooklyn.

Charles E. Sellen has been named manager of manufacturing at Wilshire Oil Co. of Calif.'s refinery in Santa Fe Springs. Sellen replaces **J. W. Whitehurst** who is returning to Malco Refineries, Inc., Roswell, N. M.

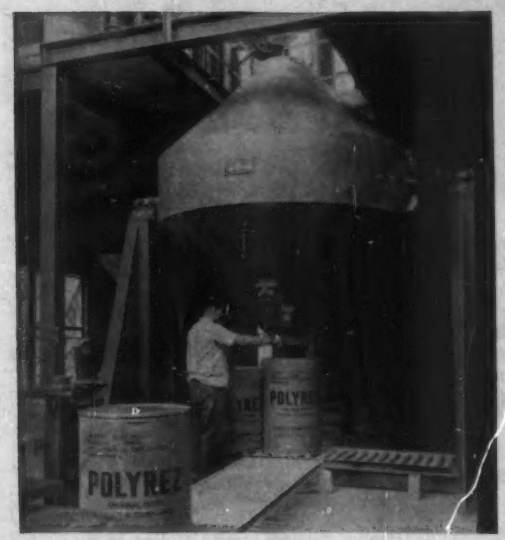
Formerly assistant manager of manufacturing, Sellen has been with Wilshire for twenty years.

Irving Leibson has been promoted to technical specialist in Technical Service division at Humble Oil & Refining Co.'s Baytown, Texas, refinery. He is specializing in the development of new chemicals from petroleum. Leibson holds B. Ch. E. and M. Ch. E. degrees from University of Florida, and B. S. and D. Sc. degrees in chemical engineering from Carnegie Institute of Technology.

H. C. Moran has been promoted to safety engineer for Humble's Southwest



Patterson gives POLYREZ 70% REDUCTION IN BLENDING TIME with the famous THORO BLENDER®



This deep cut in processing time represents for Polyrez Company, Woodbury, New Jersey, the difference between earlier spiral blending of phenolic resins and today's rapid ThoroBlender operation. Previous production difficulties included product caking and loading limitations. Now, very large batches of completely homogeneous blends are obtained in record time with the ThoroBlender, even with additives as small as 2%. For fast, gentle, thorough mixing—independent of flow properties of your material or variations in particle size—put the Patterson ThoroBlender to work in your plant. A Patterson engineer will be glad to arrange for test blending of your materials in our laboratory and discuss the data with you. Write.

ADVANCED PROCESS EQUIPMENT OF ENDURING SATISFACTION

THE Patterson FOUNDRY AND MACHINE COMPANY

A Subsidiary of Ferro Corporation

East Liverpool, Ohio

THE Patterson FOUNDRY AND MACHINE COMPANY (CANADA) LIMITED

Toronto, Ontario

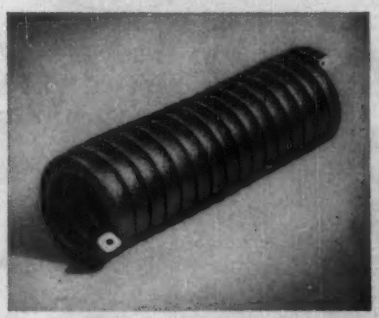
Where Temperatures and Pressures "GET HIGH"

...you need these packings!

Style HP-2M – excels against severe temperatures and pressures. A braided asbestos packing reinforced with a monel wire insertion. For use on centrifugal and reciprocating pumps, valve stems, expansion joints, etc.

Style No. 30 – a very dense braided asbestos packing, highly resistant to high pressures. For use against petroleum products at high temperatures and pressures.

Style HP-RC – a wrapped asbestos cloth packing with a resilient rubber core. For use on steam hammers, expansion joints, pumps and piston rods calling for high pressure steam, air and gases at temperatures to 600 degrees F.



Style HP-RB–for high pressure steam service up to 600 degrees F. Constructed with a core of accordion-folded asbestos cloth and a resilient rubber back, around which is wrapped a closely woven asbestos cloth jacket.

Aquapak Hydraulic Packing – a semi-metallic packing designed to withstand severe hydraulic pressures. Will give satisfactory service on pressures as high as 10,000 pounds. For use against hot and cold water on centrifugal and reciprocating pumps, outside packed boiler feed pumps and similar equipment.

ALLPAX

"The Packing that Packs All"

SEND FOR OUR NEW CATALOG — TODAY!

A complete line of packing, tools, gasket materials
Distributors in principal cities

THE ALLPAX COMPANY, INC.
160 Jefferson Ave., Mamaroneck, N. Y.
CANADIAN DISTRIBUTORS: Albion Asbestos Packings Ltd., Montreal 8, Quebec

Men in the Industry . . .

Texas division with headquarters at Corpus Christi. He was a student at Texas A&M College before joining Humble at Baytown in 1936.

Dr. Gordon H. Stillson of Gulf Research & Development Co., with laboratories in Harmar Township, Pa., has been named business manager of the research center. He succeeds **Horace W. Daugherty**, who retired February 28, after almost 46 years of service with the Gulf Oil Corp. and Gulf Research.

Dr. Stillson has been assistant director of the Business Management division for the past ten years. He did both undergraduate and graduate work at the University of Chicago, where he received a Ph. D. degree in organic chemistry in 1933. He joined Gulf as a research chemist in 1934.

Douglas P. Bailey has been named manager of the purchasing department, The Texas Company, with headquarters in New York. Bailey succeeds **Howard S. McCray**, who was elected chairman of the board of directors and chief executive officer of The Texas-Zinc Minerals Corp. in February.

Bailey joined Texaco in 1927 after receiving a B.S. degree in chemical engineering. He was manager of the operations division in the refining department prior to his latest appointment, and was assistant works manager of the Port Arthur works for 12 years before heading the refining departments' operations division.

P. C. Spencer, president of Sinclair Oil Corp., has been elected treasurer of the American Petroleum Institute.

Spencer succeeded **B. B. Jennings** of Socony Mobil Oil Co., who retired recently. Jennings had been treasure of the Institute since 1949.

Spencer previously had served two one-year terms as chairman of the API Board of Directors and two one-year terms as API vice president for transportation.

Dr. Jesse Coates, professor of chemical engineering at Louisiana State University, has been honored as the first recipient of the Charles E. Coates Memorial Award, which honors his father.

The newly-established award consisting of a bronze plaque and $100 was presented to Dr. Coates by **President Troy H. Middleton** of LSU on behalf of the Baton Rouge chapters of the ACS and the AIChE.

The award honors the late Dr. Charles E. Coates, prominent in Louisiana chemistry and chemical engineering. He was head of the LSU chemistry department for more than 40 years and dean of the Audubon Sugar School. The LSU chemistry laboratory is dedicated to him.

The new award will be presented annually to a leading chemist or chemical engineer in the Baton Rouge area. The selection is based on his contribution to chemistry or chemical engineering, including publications, professional society and community activities.

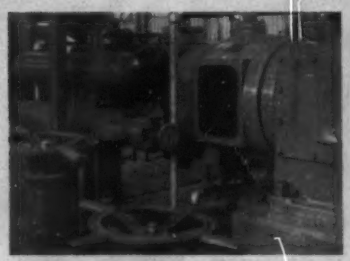
Dr. Coates was selected for the award for his research contributions in the fields of liquid-state physical properties, simplified chemical engineering calculations and thermodynamics of solutions.

For more data on advertised products, use Readers' Service Cards, last page.

Pointer oscillation only a minor reason for dampening of industrial thermometers

It is generally assumed that industrial thermometers are silicone dampened solely to prevent pointer oscillation when used on vibrating equipment. True, the prevention of pointer oscillation is necessary, but actually there are several far more important reasons for the use of silicone dampening fluids.

The primary reason for dampening bimetallic dial thermometers is to preserve accurate calibration, especially on the lower temperature ranges where a thinner bimetal element is used. An *un*dampened bimetal element, when subjected to shock or severe vibration, would have a tendency to unwind slightly, throwing the instrument out of calibration. To prevent this, thermometers are dampened by covering the bimetal element with silicone fluid. The silicone provides permanent protection for the critical bimetal element, holding the coil in place and preventing any unwinding or shifting action. This dampening, of course, also prevents pointer oscillation, eliminating difficult readings. But the primary reason for silicone dampening is to help maintain calibration accuracy, and it is therefore quite important to *all* industrial thermometer users.



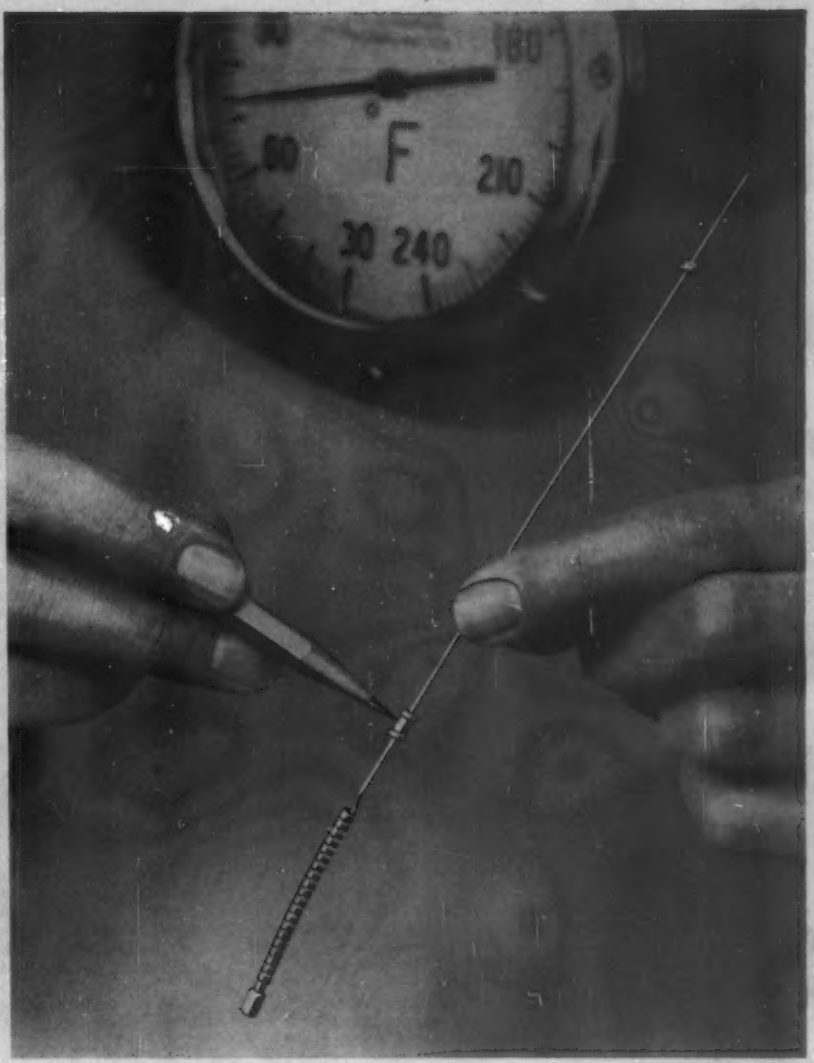
The RMC thermometer in this photograph is constantly subjected to extreme vibration. It is installed on a two-stage Synthesis Gas Compressor in Atlantic Refinery's Philadelphia Synthetic Ammonia Plant. Only a completely dampened thermometer could maintain its accuracy under such conditions.

There is more, however, to the full dampening story. Rochester Manufacturing Company carries this dampening procedure one step further with a specially designed bearing which further dampens both the shaft and coil. It also serves as a better guide for the bimetal shaft to keep it perfectly aligned within the tube. RMC is the only manufacturer using this type of dampening bearing at the present time.

RMC offers compensated electrical remote-reading liquid level indicator

A double coil movement in the RMC electrical, remote-reading liquid level indicator compensates for voltage changes. Silicone dampened and hermetically sealed.

Write, wire or phone—tell us your requirements for indicating instruments, and let RMC engineering skill go to work for you. ROCHESTER MFG. CO., 38 Rockwood St., Rochester 10, N. Y.



This special dampening bearing goes one step beyond silicone in the dampening of RMC thermometers. Only RMC uses this *extra* dampening device in addition to silicone and the usual stamped guide bearings. It is a precision machined part, serving several needed dampening functions.

Special bearing *plus* silicone double-dampens RMC thermometers

In RMC bimetal thermometers a specially designed dampening bearing is used just above the bimetal element. This bearing further dampens the shaft, helps to prevent coil unwinding and pointer oscillation, and also serves as a better guide for perfect shaft alignment within the tube. It's the combined use of this dampening bearing *and* silicone that makes RMC thermometers extra resistant to shock and vibration. You get this *only* in RMC industrial thermometers.

RMC

ROCHESTER MANUFACTURING CO., INC.
38 ROCKWOOD STREET • ROCHESTER 10, N.Y.

LIQUID LEVEL, TEMPERATURE and PRESSURE INSTRUMENTS

REPRESENTATIVES IN ALL PRINCIPAL CITIES

For more data on advertised products, use Readers' Service Cards, last page.

What Suppliers Are Doing . . .

Barbour

Henry J. Barbour, recently manager of advertising and public relations for Fairbanks, Morse & Co., will join Donahue & Coe's Chicago staff on June 1. He will serve as account supervisor and specialist on trade, industrial, and engineering media.

Barbour joined Fairbanks, Morse & Co. in 1924 as advertising manager of their Dealer division at their Beloit, Wisc., works. In 1928 he transferred to Chicago as manager of public relations. In 1954 he became manager of advertising and public relations.

Wilson

John P. Wilson has been appointed Eastern manager of petroleum sales for Blaw-Knox Co.'s Chemical Plants division. His headquarters will be in the company's New York office, and he will be responsible for petroleum engineering sales along the Eastern Seaboard. Wilson comes to Blaw-Knox after 12 years association with the Lummus Company where he held responsible positions in sales, and process and project engineering. His experience also includes four years of chemical production, plant construction, plant start-up procedure and equipment testing with U. S. Rubber Company.

Crane

Robert D. Crane has been appointed assistant director of purchases for Dresser Industries, Inc., of Dallas. He was formerly manager of purchases for Dresser Manufacturing division, Bradford, Pa. The new assistant director is a graduate of the University of Pennsylvania with a B.S. degree in mechanical engineering. Prior to joining Dresser Manufacturing division, he had been with the Morgan Engineering Co., E. I. duPont de Nemours & Co., and Mack Manufacturing Co.

Crane's chief responsibilities will be in the fields of purchasing methods and procedures, value analysis programs and inventory control.

Fellows

William H. Fellows has been named national sales manager of the Ohio Injector Co. He was formerly located at Washington as an engineer with the National Bureau of Standards, and most recently has been a vice president of Abrasive and Metals Products Co., Detroit.

Fellows is a graduate of University of Illinois engineering school and did engineering graduate studies at the University of Chicago. In his new assignment he will supervise marketing aspects of a program aimed at intensifying engineering and marketing services to the petroleum and chemical industries.

Dilger

Robert J. Dilger has been appointed director of purchases for Tube Turns, Louisville, Ky., a division of National Cylinder Gas Co. He has been in charge of purchasing for the Girdler Corp. and Tube Turns since 1942. He first joined Girdler in 1929, the year it was organized, and rejoined the firm in 1934 following four years in the purchasing department of Louisville Gas and Electric Co.

Harold Michel has been appointed vice president in charge of sales of the newly formed Midco Valve & Fittings, Inc., Evanston, Ill. Michel has been a member of the parent company, Midcontinent Tube Service, Inc., for the past three years. Previously he was general manager of the Alan Supply Co., Jersey City, N. J., and of the Wayne Valve and Fitting Corp., Chicago.

Michel

James M. Gavin, U. S. A. (Ret.) has been elected vice president and a director of Arthur D. Little, Inc. He will assume his duties as an administrative officer of the company June 1, at Acorn Park, the ADL research center in West Cambridge, Mass.

Prior to his retirement on March 31, Gavin was Army chief of research and development. He joined the Army 34 years ago as an enlisted man. After graduation from the U. S. Military Academy, he participated in the early developments of airborne warfare, becoming Commander of the 82nd Airborne Division during World War II.

Gavin

M. Mark Watkins has been appointed president of Conoflow Corp. He has a background of financial, organizational, and engineering experience, and has served as executive vice president and treasurer of Conoflow since the company was founded in 1943. In 1956, Conoflow became a subsidiary of the Walworth Co. Watkins continued as executive vice president and a director of Conoflow. At that time he was also elected to the board of directors of the Walworth Co. Watkins is also vice president and a director of the Remington Corp., Auburn, N. Y.

Watkins

Lester J. Miller has been named executive vice president of the A. P. Green Fire Brick Co., Mexico, Mo. He joined the Green Co. in 1923 as a shipping and production clerk. In 1926, he was appointed superintendent of A. P. Green's Josephine plant, and in 1927 he was appointed general superintendent. During the next several years, he handled special assignments relating to sales, engineering, and management.

In 1942 Miller was elected vice president and was appointed director of manufacturing in 1947. He became vice president in charge of operations in 1954, followed by his election in 1957 to the board of directors.

Miller

Edwin H. Krieg, vice president and consulting engineer of Stone & Webster Engineering Corp., has been elected a director. He graduated from Cornell University in 1922 with a B.S. degree in mechanical engineering and began his career as a field engineer with Sanderson & Porter. From 1925 to 1933, he was a project engineer with Electric Bond & Share Co., of New York.

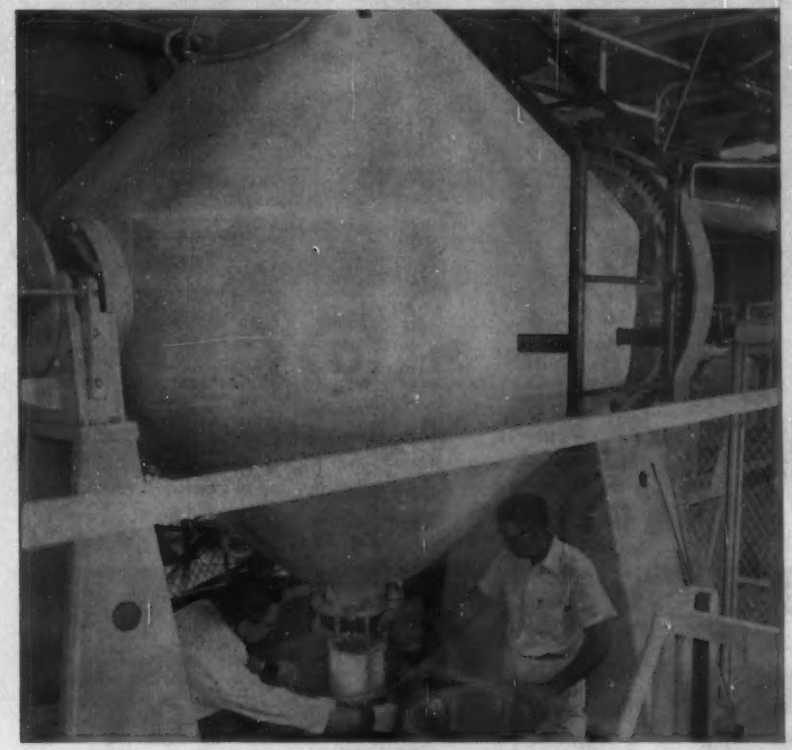
From 1933 to 1948 he was with American Gas & Electric Service Corp., as a mechanical engineer and chief design en-

Krieg

Corrosioneering News

Quick facts about the services and equipment available to help you reduce corrosion and processing costs.

Published by The Pfaudler Co., a division of Pfaudler Permutit Inc., Rochester, N.Y., U.S.A.



Now Upjohn saves 32 hours drying 2500 pounds of Orinase

Sixteen hours are all it takes for the Upjohn Company to dry and blend 2500 pounds of Orinase in the Pfaudler conical dryer-blender.

It used to take forty-eight hours to dry that much of Upjohn's oral antidiabetic in two straight vacuum dryers.

Upjohn says it also saves eight hours a week in materials handling time with the new dryer.

Since it's a pharmaceutical, the product poses a purity problem which is nullified by the noncontaminating glassed-steel construction of Pfaudler dryer-blenders.

Other companies, many handling corrosives, report similar savings, some of them cutting drying time by as much as 90%. The smooth glassed surfaces of the drying chamber are insensitive to all corrosives except hydrofluoric acid and hot alkalies above pH12.

The Pfaudler design offers a solid, one-piece drying chamber which offers maximum strength and drying area unbroken by joints or clamps. The vacuum exhaust tube is centrally located for the most efficient vapor removal.

There's much more about the Pfaudler dryer-blender that proves its efficiency of operation over other designs . . . all of it in Data Sheet 26 which you'll find offered in the coupon.

Corrosion resistance of glassed steel unimpaired by gamma radiation

No adverse effects could be detected from the exposure of Pfaudler glassed steel to 10^{10} roentgen of gamma radiation. Tests were recently completed by Pfaudler in cooperation with Oak Ridge National Laboratory and other installations.

Glassed steel is being considered for chemical processing involving nuclear energy wherever corrosive conditions are particularly severe and ease of decontamination is important.

Probable uses of glassed steel in this field include storage of acids and other materials which may or may not be radioactive, storage and disposal of radioactive wastes, and chemical processing of highly radioactive and corrosive materials.

A larger test program is now under way to follow up the preliminary results and to determine even more conclusively the effect of radiation on glassed metals.

"Is Pfaudler making Sputniks?"—This was an oft heard question recently from visitors to our Rochester plant. What they saw was this unusual new cone bottom reactor we fabricated and glassed for a leading chemical producer. All those nozzle openings on the conical surface made glassing a little "touchy," so it took us a little longer than with standard models. The vessel is 388 inches long with a 138-inch OD, and will be used for storing and purging polymer chips at 160°F. An internal column does the purging with an inert gas.

Why do we show it here? To suggest that we can put the corrosion resistance of Pfaudler glass to work on more than conventional reactors, storage tanks, columns, etc.

THE PFAUDLER CO.
a division of PFAUDLER PERMUTIT INC.
Dept. PR-58 Rochester 3, N.Y.

Please send information on: ☐ Conical Dryer-Blenders ☐ Pfaudler Buyer's Guide.

Name.....

Title.....

Company.....

Address.....

City.....Zone.....State.....

For more data on advertised products, use Readers' Service Cards, last page.

Oe 649 .1e

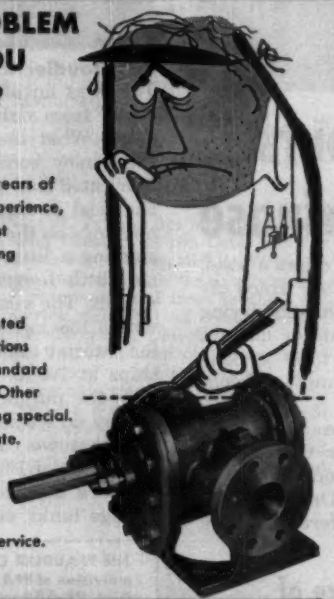
Oil refineries

in many countries successfully equipped their modern plants with B&R Gate Valves, Globe Valves, Swing Check Valves, Safety Valves. B&R Valves are manufactured according to API specifications. Flange dimensions conform to ASA. Materials correspond to ASTM. One trial with our Valves will make you our customer for ever. Please ask for B&R catalog We 110e with detailed particulars on our lines of **oilfield and refinery equipment.**

BOPP & REUTHER G·M·B·H MANNHEIM - WALDHOF

WESTERN GERMANY

PUMPING PROBLEM GIVING YOU TROUBLE?



Get *qualified* help.
Tell us about it.
SK Gear Pumps, product of years of research and engineering experience, are solving problems in almost every industrial field—pumping many types of materials like alcohol, fuel oils, glue, wax, lube oils, resins, cellulose, heated oils, road tars. Some applications require only a top-quality standard pump. Ours are top-quality. Other applications demand something special. If so, we're ready to cooperate.

We'd like to get acquainted —let us send you Bulletin 17-A describing our pumps and engineering service. Just write us. We'll send it.

Schutte and Koerting COMPANY
MANUFACTURING ENGINEERS
2257 STATE ROAD, CORNWELLS HEIGHTS, BUCKS COUNTY, PA.

Jet Apparatus: Ask for Condensed Bulletin J-1.	Rotameters & Flow Indicators: Ask for Condensed Bulletin 18-RA.	Valves: Ask for Condensed Bulletin V-1.	Heat Transfer Apparatus: Ask for Condensed Bulletin HT-1.	Gear Pumps: Ask for Bulletin 17-A.

WHEN SPECS CALL FOR...

HEAT EXCHANGERS

custom fabricated on the West Coast

Save on transportation costs, manufacturing time and put yourself in a more competitive position by contacting an experienced "on the spot" source when planning the procurement of process and plant equipment for the West Coast. Send prints for prompt quotation on your next job.

Request Brochure No. K-57

PUGET SOUND FABRICATORS, INC.
PSF SINCE 1900
Craftsmen in Metals
3670 E. Marginal Way • Seattle 4, Wash.
Craftsmen in steel plate and alloys up to 1"

Suppliers . . .

gineer. During this period he was responsible for designing power plants with a total capability of more than 2 million kilowatts.

Since joining Stone & Webster in 1948 as a consulting engineer, Krieg has worked as a general consultant in various parts of the country.

B-I-F INDUSTRIES, INC. has named **Daniel L. McGuiness, Jr.,** as development coordinator for Proportioneers, Inc., responsible for overseeing all development activities in that division. McGuiness has a B.S. degree in electrical engineering from Massachusetts Institute of Technology and a M.B.A. degree from Boston University. He formerly worked for Standard Coil Products Co., Inc., as engineering products manager, and Corning Glass Works as an engineer.

AMERICAN CYANAMID CO. has named **Luther E. Beiswanger** director of industrial engineering for the Organic Chemicals division. With Cyanamid since his graduation in 1940 from the University of Minnesota, Beiswanger has served in various technical and managerial posts.

Donald M. Roberts has been named assistant to the advertising manager, Organic Chemicals division. A graduate of Clark University, Roberts has done extensive development and technical service work since joining Cyanamid.

GRAVER TANK AND MANUFACTURING CO. has been awarded the enclosure shell contract for the $29 million experimental breeder reactor to be built at the Atomic Energy Commission's National Reactor Testing Station near Idaho Falls, Idaho.

The Argonne National Laboratory, Lemont, Ill., has been authorized by the AEC to proceed with construction of the reactor.

The contract calls for a 1-inch thick steel containment vessel, 80 feet wide and 139 feet high. A pit will be dug for the enclosure shell and a 200,000-gallon flat bottom water storage tank will be built. The project is scheduled for 1960 completion.

THE GARLOCK PACKING CO. has announced the appointment of William Sheffeld to the post of treasurer of the company. Sheffeld is presently a vice president.

THE RIDGE TOOL CO. has named Carl H. Ingwer, founder and president of the company, chairman of the board. Succeeding him as president is Joseph A. Frates who also becomes general manager.

The new president has been with the company since 1946 and a member of the board for 12 years. He was elected assistant secretary in 1949 and became a vice president in 1952. Frates is a graduate of Phillip Exeter Academy at Exeter, New Hampshire, and Principia College at Elsah, Ill. During World War II he saw service with the Air Force in Europe and Africa.

THE OHIO INJECTOR CO. has named **Bertram J. Milleville** director of engineering and research. He will head the company's recently announced product development program.

Milleville is credited with the develop-

EXCLUSIVE WITH TIDEWATER DELAWARE CITY REFINERY—
141 DUCON CYCLONES INSTALLED FOR CATALYST RECOVERY

High Efficiency Attested by Leading Oil Refineries . . .

DUCON CATALYST RECOVERY CYCLONES

Recovery of valuable catalyst in regenerator and reactor systems makes a big difference in the efficiency and costs of oil refining. Ducon Type SDC Cyclones, with the exclusive helical inlet feature, have proved themselves the world over for their dependable high operating effectiveness, and maximum catalyst recovery for constant reuse.

TYPICAL APPLICATIONS
for Ducon Cyclones and Trickle Valves
FLUID CATALYTIC CRACKING • FLUID COKING
FLUID HYDROFORMING • ELUTRIATOR TOWERS
THERMOFOR CATALYTIC CRACKING
ALL FLUID SOLIDS PROCESSES

Ask for Descriptive Bulletin No. CV-2506

DUCON

the name in DUst CONtrol

THE Ducon COMPANY INC.
147 EAST SECOND STREET • MINEOLA, L. I., NEW YORK

CYCLONES • CENTRIFUGAL WASH COLLECTORS • TUBULAR CLOTH FILTERS • DUST VALVES

Suppliers . . .

ment, and he holds several patents, on valves used in the petroleum and chemical industries. He comes from a similar position with Edward Valves Co., Chicago. He has a M.S. degree from Massachusetts Institute of Technology, and was graduated in engineering from Illinois Institute of Technology.

HILLS-McCANNA CO., Chicago, has made **Etablissements A. Bruyaux** its exclusive representative in Belgium, France, Holland and Luxembourg.

THE FAIRBANKS CO. has announced these changes in sales assignments in the Philadelphia sales office: **William R. Bieretz** from Fairbanks' materials handling equipment to valves and dart unions and **Ellis F. Hendricks** to Fairbanks' trucks, casters and wheels.

Bieretz has been selling two-wheel and platform hand trucks, casters and wheels in the Philadelphia territory for the past eight years. He will now be concerned with the sales of bronze and iron-body valves and dart unions.

Hendricks has a background of ten years in the construction industry and 1½ years with an industrial concern. He will be responsible for the sale of trucks, casters and wheels, working out of the Philadelphia sales office.

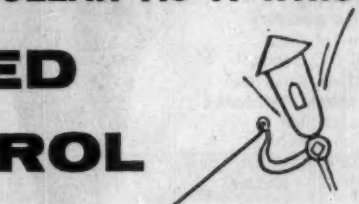
CONOFLOW CORP. has made **M. Mark Watkins** president of the company. He has a background of financial, organizational, and engineering experience, and served as executive vice president and treasurer of the company. He has been a member of the board of directors of the Walworth Co. and vice president and director of the Remington Corp., Auburn, N. Y., manufacturer of room air conditioners.

Prior to joining Conoflow in 1943, Watkins was executive vice president of Peoples Bond and Mortgage Co., Philadelphia. Earlier, he was export sales manager for the Carrier Co.'s International division, and branch manager and director of foreign sales, Brown Instrument division, Minneapolis-Honeywell.

Watkins received his chemical engineering degree from the University of Pennsylvania in 1921.

NOW! Get CLEAN-AS-A-WHISTLE

WEED CONTROL



In Non-Crop Areas

- ☐ tank farms
- ☐ pipelines
- ☐ pumping stations
- ☐ firebreaks
- ☐ fence rows
- ☐ paths and roads
- ☐ drainage ditches

with amazing new **UROX®** **WEED KILLER**

Longer lasting! Saves time and money! Now you can control troublesome vegetation *for a longer time and at lower cost* than ever before—with UROX, General Chemical's sensational new weed killer.

You need only one application a year under normal growing conditions! Small quantities do the job! And results "carry over"! Light "booster" doses keep most areas weed-free from season to season. Easy to use, too!

Write for complete information

Allied Chemical

GENERAL CHEMICAL DIVISION
40 Rector Street, New York 6, N. Y.

JONES & LAUGHLIN CORP.'S supply division announced that **H. L. Wilkins**, Canadian manager of operations for the firm, has retired after 44 years of continuous service. **V. H. Weldon, Jr.**, formerly assistant manager, has been promoted to regional manager replacing Wilkins.

Wilkins

Wilkins joined the Atlas Supply Co. (later bought by Jones & Laughlin) in 1914. He served as salesman at Nelagony, Pawhuska and Cleveland, Okla., and as store manager at Okmulgee, Okla. He later served as district sales manager for the Southern Oklahoma district, the Central Oklahoma district and the Kentucky and Illinois district.

In 1941 Wilkins was promoted to manager of branch stores with headquarters at Tulsa. He became assistant sales manager for J&L Supply in 1947 and in 1949 was appointed manager of Canadian operations with headquarters at Calgary.

COOPER-BESSEMER CORP. has appointed **Robert L. Kietzman** sales engineer for the St. Louis branch office.

Kietzman

Kietzman will be responsible for engineering and sales contacts with users of compressors and engines in the Missouri and Southern Illinois areas. A graduate of Oklahoma State University, Kietzman holds a B.S. degree in industrial engineering. He joined Cooper-Bessemer upon graduation and has been associated with the company's product departments for the past two years.

PETROLITE CORP.'S California division has named **W. Wallace Anderson** plant manager. He succeeds **C. N. Stehr**, who is now on special assignment for Petrolite Corp.

Anderson joined Tretolite Co. of California in 1935 and was employed in research and development for more than 11 years. In 1947 he became assistant plant manager. He is a registered chemical engineer in the state of California.

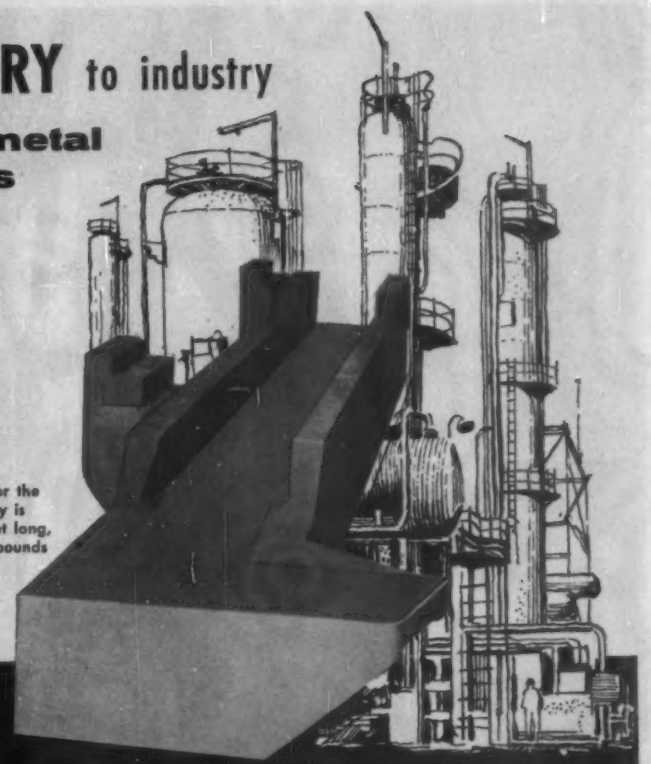
The position of assistant plant manager

from SERVICE FOUNDRY to industry

a complete line of metal fabricating facilities

- Design for iron, steel and non-ferrous castings
- Pattern making
- Electric arc and gas-fired crucible furnaces
- Casting
- Testing apparatus—radiography, magnaflux and zyglow
- Heat treating
- Machining, fabricating and welding

write the Industrial Contracts Division of Avondale Industries for our free Brochure, *Foundry Work — Steel, Alloys and Non-Ferrous, Vol. 6.*



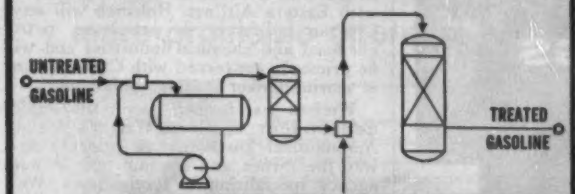
This large casting for the Petroleum Industry is approximately 16 feet long, weighs about 7000 pounds

SERVICE FOUNDRY

416 Erato Street • New Orleans, La., USA
JA 2-3836 • Cable Address: "SERFDRY"

a division of AVONDALE MARINE WAYS, INC.

TG SWEETENING



TENNESSEE COPPER CHLORIDE

Tennessee's Copper Chloride was developed to effect efficient Mercaptans removal.

Place your confidence in a basic producer of Copper Chemicals.

CUPRIC CHLORIDE DI-HYDRATE

Other products of interest—
Ferric Sulfate—Copper Sulfate,
Copper Oxide—Sulfur Dioxide.

For samples make request on your company letterhead.

TENNESSEE TG CORPORATION
617-629 Grant Building, Atlanta, Ga.

Don't spoil it- KROIL it!

Don't ruin a valuable piece of equipment merely because some part is rusted tight. Apply *KROIL*, the amazing new chemical lubricant that creeps into millionth inch spaces (proved by laboratory tests), dissolves rust, supplies necessary lubrication and . . .

Loosens Frozen Parts

18,000 of America's leading plants can't be wrong. They have used KROIL for ten years and depend on it to save expensive labor and valuable parts. They say: "Kroil loosened bushings after a 12-ton press had failed" . . . "on repairing heat treat trolleys formerly destroyed every nut. Now Kroil saves them all, and time, too."

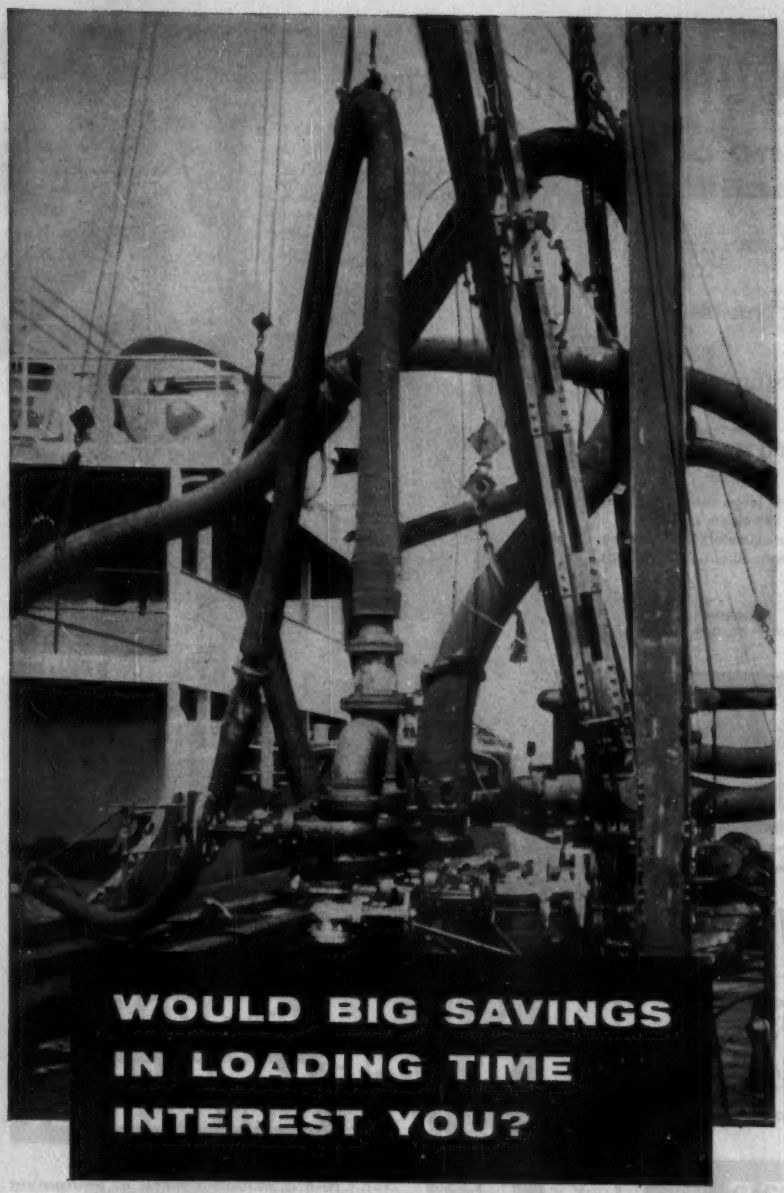
You too can get these results. Try KROIL on money-back basis.

Gallon, $4.00; with Kroiler squirt gun, $4.95, f. o. b. factory.

Ask for GENIUS AT WORK—a free publication full of ideas for maintenance men.

KANO LABS. 1094 Thompson Lane Nashville 11, Tennessee

For more data on advertised products, use Readers' Service Cards, last page.



You can save up to 50% of the time required for loading and unloading petroleum products with Hewitt-Robins "Monarch" oil suction and discharge hose. It has a smooth bore that cuts frictional resistance to a minimum and is lighter in weight and easier to handle than rough bore hose.

Because the tube in this super-tough, wire-reinforced hose is permanently bonded to the carcass by a special H-R process, Monarch has replaced competitive rough bore hose in many installations. Fittings are also permanently bonded through the exclusive H-R Durabond process, and cannot pull loose even under severest strain. To find out how H-R products and services can help you, consult your classified telephone directory for the nearest H-R representative, or contact Hewitt-Robins, Stamford, Conn.

HR HEWITT-ROBINS

CONVEYOR BELTING AND IDLERS... POWER TRANSMISSION DRIVES
INDUSTRIAL HOSE... VIBRATING CONVEYORS, SCREENS & SHAKEOUTS

Suppliers . . .

vacated by Anderson will be filled by **Claude D. Thompson**, who has been with Tretolite Co. of California since World War II as plant operator, draftsman, engineer, and division safety director.

THE COOPER-BESSEMER CORP. has named **James H. Caldwell** district service manager, Pacific Coast. Caldwell will be responsible for the supervision of all Cooper-Bessemer service activities in the Los Angeles, Seattle, San Francisco and Casper, Wyo., areas.

Caldwell

A graduate of Ohio State University, Caldwell holds a B.S. degree in mechanical enginering. Since his graduation in 1936, he has been associated with Cooper-Bessemer, having served in its Research, Production Testing and Service departments. He will work under the direction of **James W. Reed**, vice president and Pacific Coast manager of Cooper-Bessemer.

CHIKSAN CO. has named **Charles J. Holcomb** senior field engineer and **H. Wilson Werhan** field engineer. Both have been assigned to the firm's Newark, N. J., branch office and will work under **J. F. Powers, Jr.**, Eastern regional sales manager.

Holcomb transferred to Chiksan from its Well Equipment Mfg. Corp. division, with whom he has been associated for nine years, the last six as industrial sales representative for Chiksan and Weco products in the Gulf Coast area. He was previously with Eastern Airlines. Holcomb will serve Chiksan customers in petroleum, petrochemical and chemical industries and will be primarily concerned with Chiksan's line of marine tanker loading equipment.

Werhan was formerly with the service department of Curtis-Wright's Wright Aeronautical Division, and prior to that was the owner and operator of an auto agency specializing in foreign cars. Werhan will serve Chiksan accounts in the guided missile and aircraft industries and will be concerned with Chiksan products used in missile fueling and launching and ground support equipment, as well as airborne swivel joints.

BLAW-KNOX CO.'S Buflovak Equipment division has appointed **Clarence E. Becker** manager of manufacturing. He joined Buflovak in 1936 as a time study engineer, holding the positions of supervisor of industrial engineering, chief industrial engineer and manager of industrial engineering. He attended the University of Buffalo.

DRESSER INDUSTRIES, INC.'S recently elected board of directors for 1958 comprises:

H. N. Mallon, chairman of the board; **Norman Chandler**, Los Angeles, president and publisher, The Los Angeles Times; **Henry P. Isham**, Chicago, president of the Clearing Industrial District, Inc.; **Willard M. Johnson**, Houston, president of the Magnet Cove Barium Corp.; **John Lawrence**, Dallas, executive vice president, Dresser Industries, Inc.; **L. W. Mac-**

WACO

T.M. REG. CANADA

Aluminum Grating

for ramps, walkways, pit covers, floorings, etc.

Patented Upset design provides sure-footed, non-skid, non-directional safety—even in the presence of wet, greasy or other hazardous conditions. Non-magnetic, non-sparking and maintenance-free! Washington Aluminum will fabricate any shape, width or length grating to answer your most exacting requirements. *FREE BOOKLET ON REQUEST.*

low as **$2.50** per sq. ft.

WASHINGTON ALUMINUM COMPANY, INC.

Dept. 55 • Baltimore 29, Md. • Phone Circle 2-1000

Chemical plant design for more profitable operations

Just Published!

Here are the essential methods for planning and setting up manufacturing operations that function profitably and make the most efficient use of machinery and components. Fully explains waste disposal, structural design, equipment fabrication, design of process equipment *—plus data required to determine if such apparatus is practical and profitable for the plant.*

PLANT DESIGN AND ECONOMICS FOR CHEMICAL ENGINEERS

By **MAX S. PETERS,** *Registered Professional Engineer*
Associate Professor of Chemical Engineering, University of Illinois

503 pages, 6 x 9, 204 charts, tables, and illustrations, $11.00

Here are the pitfalls to avoid in selecting the plant location, how to reduce fire and explosion hazards, what constitutes an infringement of patent rights, the best methods for the disposal of toxic materials, how to handle erosion and corrosion in plant equipment, how to estimate the bursting pressure of a thin-walled cylinder, what means can be used to eliminate dirt and scale on heat-transfer surfaces, how to estimate pressure-drop in packed towers, and a host of other techniques for handling the problems of plant equipment design and operation.

You'll see just how to prove if a plant design is profitable and practical, and if its equipment will put the operation on a paying, proficient basis; the 16 important factors affecting plant layout, and how scale-models can be put to work for higher plant efficiency—everything you need to know to take full advantage of modern plant methods.

THE GULF PUBLISHING COMPANY

P. O. Box 2608, Houston 1, Texas

Now this popular self-contained 1" to 2"

RIDGID 65R-TC

offers you 3 exclusive advantages

1. Only die stock with True-Centering workholder—no more crooked threads, no time or pipe wasted.
2. Only Jam-Proof die stock—automatic kick-out after standard thread is cut by hand or power.
3. Threads 4 sizes of pipe with 1 set of dies—quick size change. Dies for stainless steel available.

See 65R-TC before you buy—at your Supply House

The Ridge Tool Company, Elyria, Ohio, U.S.A.

For more data on advertised products, use Readers' Service Cards, last page.

Suppliers . . .

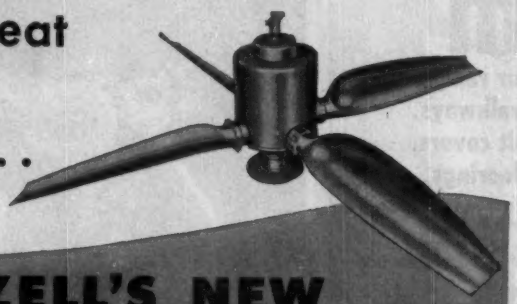
Naughton, Dallas, board chairman, DeGolyer & MacNaughton; **William A. McAfee,** Cleveland, senior partner, McAfee, Grossman, Taplin, Hanning, Newcomer & Hazlett; **J. B. O'Connor,** Dallas, president, Dresser Industries, Inc.; **R. E. Reimer,** Dallas, executive vice president, Dresser Industries, Inc.; **Tom Slick,** San Antonio, chairman, Slick-Moorman Oil Corp.

Lawrence is a new director.

GENERAL ELECTRIC CO.'S Computer department will begin construction of a permanent plant in Deer Valley Park, near Phoenix, Ariz. this month. General Manager **H. R. Oldfield, Jr.,** announced approval by the company's board of directors of an initial 104,000 square foot structure. Oldfield said the building will bring the permanent investment of the Computer department in the Phoenix area to $4 million. Occupancy is scheduled for January 1959.

JEFFERSON CHEMICAL CO., INC., has named **Howard A. Tenney** manager, antifreeze sales. Tenney will be responsible for promoting the sale of antifreeze glycol. He attended the University of Texas, and received B.S. degree in chemistry, biology and psychology from the University of Houston in 1947. He has been assistant sales manager, Monsanto Chemical Co., Texas City.

for peak heat exchanger efficiency . . .



HARTZELL'S NEW CONTROLLABLE PITCH FAN

The Hartzell Controllable Pitch Fan meets a long-standing need in the petroleum industry for a precise method of controlling a variable flow of air to maintain predetermined temperatures. On test installations, these new fans have proved their ability to hold outlet temperature fluctuation to plus or minus 1½°F. And, while achieving this highly accurate level of control, they consume up to 50% less power than required by conventional fixed-pitch fans.

In a temperature sensitive control system depending on air flow, the amount of air required to achieve the necessary cooling depends on the temperature of the air. High air temperatures require high air deliveries, low air temperatures require minimum air deliveries. With a Hartzell Controllable Pitch Fan, variable air delivery is accomplished by variation in blade pitch setting. The fan assembly responds instantly and automatically to conventional temperature sensitive control equipment — increasing blade pitch to deliver more air when outlet temperature rises, decreasing blade pitch and delivering less air when outlet temperature falls.

For complete details on Hartzell's controllable pitch heat exchanger fan, write for Bulletin 111-B or call your nearby Hartzell field engineer.

HARTZELL PROPELLER FAN CO.
Division of Castle Hills Corp.
71 Thomas Blvd. Piqua, Ohio

PROCESS FABRICATORS INC., has acquired the plant and manufacturing facilities of the United Pipe Fabricating Co., Inc., of Houston.

The entire management personnel has been changed. All officers and shop supervision personnel have been engaged in the pipe fabricating field in the Houston area for many years. **G. Bryan** will be president of the company, **George E. Little,** vice president and **Edward W. Berry,** secretary and treasurer.

THE BABCOCK & WILCOX CO.'S Boiler division district sales office, Cleveland, has been moved to 1367 Illuminating Building, 55 Public Square, Cleveland 13. It was formerly at 1515 National City Bank Building, Cleveland 14.

The Charlotte, N. C., district sales office has moved to 1100 Wachovia Bank Bldg., 129 Trade St., Charlotte 2, N. C. Formerly it was located at 913 Liberty Life Bldg., Charlotte.

BURGESS-MANNING CO., Industrial Silencer division has made **J. A. Kolb** sales engineer in the New York district office and Mr. **Louis G. Halla** sales engineer in the Chicago district office.

Kolk has been a field sales engineer in the Chicago area for the past three years.

Halla graduated from the University of Illinois with a B.S. degree in civil engineering. He was formerly with the Walker Process Equipment, Inc., and Wallace & Tiernan, Inc.

CONSOLIDATED ELECTRODYNAMICS CORP. has appointed **Clifford W. Bishop** sales manager of the Analytical and Control Instrument division. **Robert D. Enochs** will succeed Bishop as manager of the company's district sales office in Dallas.

A graduate of Oklahoma State University, Bishop had been district manager in Dallas since November, 1956. He was formerly a field engineer in CEC's Southwestern regional office in Dallas. Before joining Consolidated, he was a research physicist with Continental Oil Co. and a junior physicist with Phillips Petroleum Co.

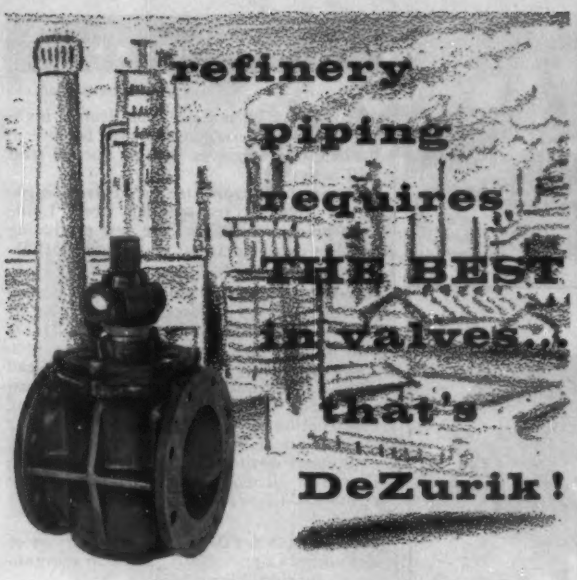
Enochs joined CEC in 1951 as an installation engineer and became a training engineer in 1952, a supervisor in instrument order service in 1953, and assistant to the director of sales in 1956.

NATIONAL CYLINDER GAS CO.'S newly formed Girdler Process Equipment division has appointed **John E. Slaughter, Jr.,** division president; **Bruce D. Miller,** vice president of manufacturing; **Allen M. Bond, Jr.,** director of engineering and product development, and **N. T. Joyner,** general sales manager. Divisional headquarters and manufacturing facilities are in Louisville, Ky.

Other appointments are: **Boyd R. Hopkins,** Thermex sales manager; **Lamar D. Roy,** Votator sales manager; **H. E. Huber,** process plants sales manager, and **E. T. Beck,** sales manager for overseas operations.

BECKMAN INSTRUMENTS, INC., is completing a $250,000 program to supply improved power-monitoring instrumentation for the Strategic Air Command's B-47 long-range jet bombers. The equipment reportedly consists of high-accuracy linear scale ammeters designed to monitor electric power systems in the bombers.

LINDE CO., a division of Union Carbide, will build an automatically-operated oxygen plant at the site of Detroit Steel Co.'s operations at Portsmouth, Ohio. The plant



NO OTHER VALVE can give you the advantages of DeZurik's EXCLUSIVE Eccentric Action in combination with resilient-faced plugs. NO OTHER VALVE can give you *tighter shut-off—easier operation—WITHOUT LUBRICATION!*

DeZurik's exclusive eccentric action pivots the plug eccentrically, matching an eccentrically-raised seat. The plug touches the body *only* when the valve is shut. In opening the valve, the plug backs away from the seat and swings aside in an easy quarter-turn . . . without friction, without binding, WITHOUT LUBRICATION!

DeZurik Valves are available in sizes ½" thru 20" in many metals and models with a full range of operators. See the DeZurik representative in your area, or write for details.

DeZURIK CORPORATION
SARTELL, MINNESOTA

So SIMPLE that "Specials" are Likely to be Standard!
A sleeve, raised and lowered within a non-magnetic tube, attracts or releases an Alnico magnet attached to a mercury switch. Basically, this is Magnetrol

MAGNETROL

The World's Most Dependable

LIQUID LEVEL CONTROL

Because of the utter simplicity of Magnetrol's magnetic operating principle, standard models can be easily adapted to meet any special requirements for pressure, temperature or corrosive liquids . . . and usually at little extra cost. This Magnetrol versatility has solved all kinds of tough level control problems . . . and given our engineers wide application experience that can be invaluable to you.

Magnetrol is so simple that failure is all but impossible! Using only permanent, unfailing magnetic force for its operation, there's nothing to wear out . . . no diaphragms or bellows to stiffen and rupture . . . no electrodes to short or corrode . . . no packing to bind or leak. Magnetrol is practically maintenance-free! Magnetrol units are available for controlling level changes from .0025-in. to 150-ft. . . . with multi-stage switching when desired. Send coupon for full details.

MAGNETROL, Inc.

Send Coupon For Full Details

MAGNETROL, Inc., 2112 S. Marshall Blvd., Chicago 23, Illinois

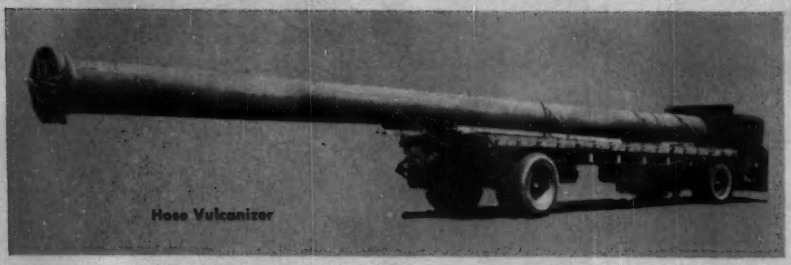
Please send me catalog data and full information on Magnetrol Liquid Level Controls.

Name_____

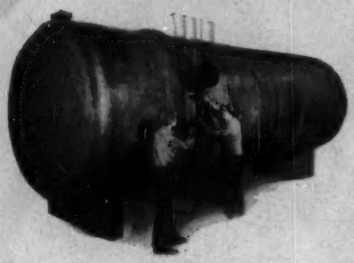
Company_____

Address_____

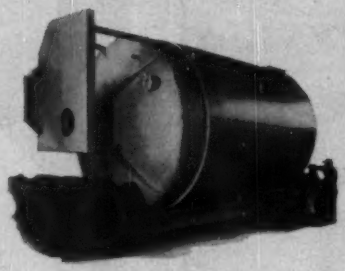
City_____ Zone____ State_____



Hose Vulcanizer



Acid tank made of steel



12' x 17' stainless clad high pressure jacketed tank

77 years of KOVEN fabricating experience built into every Job

Drying drum of stainless steel

X-RAY INSPECTION FOR QUALITY CONTROL

KOVEN equipment in all metals and alloys includes: High pressure vessels built to A.S.M.E. Codes; extractors; mixers; stills; kettles; tanks; stacks; breechings; hot transfer lines; large diameter fabricated piping and plate exhaust ducts; shop and field erected storage tanks; high vacuum testing.

SPECIALISTS IN INTRICATE FABRICATION USING:

STAINLESS STEEL • ALUMINUM • MONEL NICKEL • INCONEL • ALL CLAD MATERIALS NICKEL PLATED STEEL • JOB GALVANIZING STRESS RELIEVING

Fabrication to all A.S.M.E. Codes

Call or write for a consultation with a trained KOVEN representative, and send for Bulletin #550.

Members of Steel Plate Fabricators Association

See Sweet's File and Chemical Engineering Catalog

Stainless steel high pressure reactor—fully x-rayed seams

Koven FABRICATORS, INC

91 E. Dickerson St., Dover, New Jersey

PLANTS JERSEY CITY, N. J. • DOVER, N. J. • TRENTON, N. J.

Telephone:
New Jersey: FOxcroft 6-0400
New York: WOrth 4-7395

Suppliers . . .

will produce 20 million cubic feet of high-purity gaseous oxygen a month for use in furnace operations as well as normal steel mill activities.

Presently Detroit Steel is receiving high-purity oxygen transported from Linde mass-producing plants. The new producing plant is expected to go on-stream in 1958.

TELE-TRONICS CO., Ambler, Pa., announced the addition of **Walter E. Smith** to its staff as manager of engineering. He is also a member of the board of directors.

Smith spent the past 15 years as head of the Test Equipment department, Lansdale Tube Co. He had charge of design, construction and maintenance of electronic and electrical process control and testing equipment in the plant. He will now be in charge of all engineering and manage the electronic fabricating shop.

CHASE BRASS & COPPER CO., a subsidiary of Kennecott Copper Corp., plans to reorganize its forgings division.

E. Rowland Chase, who has been in charge of forgings sales at the Waterbury Manufacturing Co., has been transferred to the mill and warehouse sales division in the same capacity. He will be responsible for the promotion and sale of brass, aluminum and titanium forgings.

Thomas J. Marshall will assist Chase. He was most recently a sales representative in Chase's Philadelphia sales office.

The operating personnel of the forgings division, which formerly operated as a department of the Waterbury Mfg. Co., have been retained and will be headed by **G. R. Boutin** as manager. **Frank E. Wargo**, who has been superintendent of forgings for Chase, will continue in that capacity.

BARTON INSTRUMENT CORP., Monterey Park, Calif., has named **Everette M. Furr**, factory superintendent. He has been production planning supervisor for the past six years.

William S. Christian has been appointed sales manager. He joined Barton in 1949 and has been assistant sales manager since 1956.

Claude B. Nolte has been appointed vice president in charge of product engineering and development. Joining Barton in 1946, Nolte served as vice president, sales manager and vice president in charge of production.

EVER-TITE COUPLING CO. has appointed **Victor J. Carnell** Mid-West manager—sales engineer. He will have headquarters at 2107 Carew Tower, Cincinnati.

Carnell has been supervisor—Operations department, Pennsylvania division of Esso Standard Oil Co., in Philadelphia.

CONSOLIDATED ELECTRODYNAMICS CORP., Pasadena, Calif., and Cenco Instruments Corporation, Chicago, have broken off negotiations on their prospective merger. An announcement was made in January that a preliminary agreement had been reached for a possible combination of the two companies.

STAUFFER CHEMICAL CO. has appointed **Russell M. White** general manager of the International division. He will be located in the New York office and will be responsible for acquisition of rights to foreign processes and products, licensing of Stauffer products and processes in foreign

Plibrico *Refractories*

THE *"pro"* OF *proper* PRODUCTS

There's nothing amateurish about the way Plibrico refractories get the job done. That's because there are no cure-all refractories in the Plibrico line, but rather specific types and grades tailored to lining process equipment.

Here, in brief, are a few for your work.

Plicast Verilite—a light weight insulating castable of unusual characteristics, combining low "K" factor and utmost strength. Made for pneumatic application.

Plicast Petromix (Tuff-Mix G)—a first quality dense castable specifically designed for early strength in the intermediate temperature range (1000-1500 deg. F.), and for pneumatic application.

Plicast 40—one of seven abrasion resistant castables. Designed for low iron service requirements in extreme conditions. For trowel or pneumatic application.

Ask your Plibrico man for complete details. Write, too, for our catalog covering your applications.

Plibrico REFRACTORIES ENGINEERING CONSTRUCTION

PLIBRICO COMPANY • CHICAGO 14, ILL.
Plibrico Sales & Service in Principal Cities

INHIBIT DERMATITIS AND OTHER ANNOYING SKIN INFECTIONS WITH

ALL PURPOSE SKIN CLEANSER

WITH EFFICIENT DISPENSERS Portable and Stationary Throughout Your Plant

Recognized throughout industry as a superior, heavy duty paste-cream antiseptic skin cleanser, VI-LAN fortified with Lan Act 12, is properly dispensed with portable and stationary dispensers conveniently placed on work benches, service trucks, oil rigs, laboratories, store rooms, work carts, lavatories, and in EVERY WASH ROOM.

No. 50

Used WITH OR WITHOUT WATER, Vi-Lan removes greases, oils, paints, tars, acids, asphalt, pipe dope, rubber, etc., inhibits dermatitis, and serves to eliminate lost man hours and expensive compensation claims.

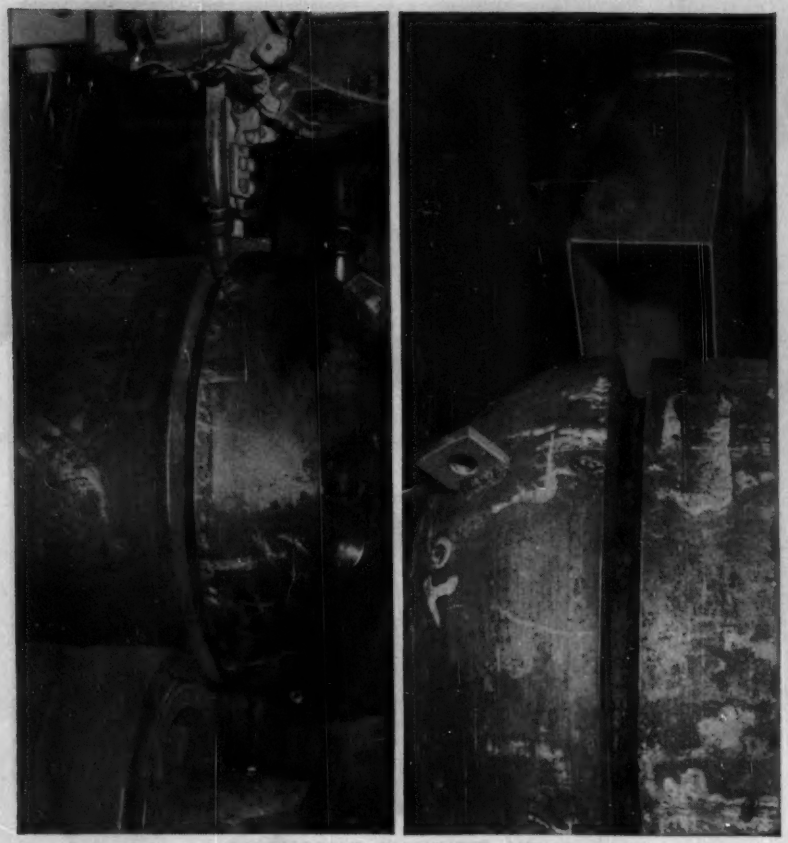
No. 60-70

It drastically reduces hand-cleaning costs and removes stubborn soils in less time than conventional soaps and detergents. IT DOES WHAT SOAP CANNOT DO and its lanolin content preserves natural skin qualities.

Write for descriptive folder: "Keep Their Hands Clean and Germ Free."

DAMERON ENTERPRISES, INC.
427 South 20th Street
Louisville 3, Kentucky

For more data on advertised products, use Readers' Service Cards, last page.



WELDING... X-RAYING...

2-inch-thick seam at Downingtown

Item: Air Dryer Cylinder
Material: Carbon Steel
Thickness: Head, 2"—Shell, 2-5/16"
Design Pressure: 3200 psi
Hydrostatic Test Pressure: 5400 psi
Design Temperature: 450° F.
Stamping: National Board and ASME

X-rayed and stress relieved. Inspection by purchaser and Hartford. One of 8 identical units. The rest of our plant equipment is geared to our capacity for welding 2-inch-thick material and lifting 80 tons. Write for bulletins; illustrating Downingtown equipment and experience.

Downingtown Iron Works, Inc.
151 Wallace Ave., Downingtown, Pennsylvania
division of PRESSED STEEL TANK COMPANY Milwaukee
Branch offices in principal cities
HEAT EXCHANGERS—STEEL AND ALLOY PLATE FABRICATION
CONTAINERS AND PRESSURE VESSELS FOR GASES, LIQUIDS AND SOLIDS

Suppliers . . .

countries, export sales, and commercial contacts abroad.

White had been manager of fertilizer promotion for Stauffer on the Pacific Coast since January, 1955. He attended Fresno State College and University of California, and spent nearly 20 years in South Africa and Europe with another chemical company.

THE HARRIS PUMP & SUPPLY CO. of Pittsburgh has been appointed regional distributor of Proportioneers, Inc., a division of B-I-F Industries, Inc., of Providence, R. I. Harris' services will be available in West Virginia, southeastern Ohio, and western Pennsylvania for users of Proportioneers' line of chemical proportioning pumps.

THE BIGGS BOILER WORKS CO., Akron, Ohio, has been acquired as a wholly owned subsidiary by the Union Spring & Manufacturing Co., New Kensington, Penn. The new subsidiary will be operated under the name of The Biggs Steel Foundry & Fabricating Co.

FISHER GOVERNOR CO., Marshalltown, Iowa, is represented in the Rocky Mountain area by another sales engineer, **Bert M. Maich,** who is with Joy & Cox, Inc., Fisher sales office in Denver. This territory covers the Rocky Mountain states from New Mexico to Montana. Maich has an engineering degree from the University of Colorado.

THERMAL RESEARCH & ENGINEERING CORP., Conshohocken, Pa. announced two new sales agency selections for its specialized combustion and fired heat equipment. Paul H. Chapman & Associates will handle the Southeast territory including Florida, Alabama, Georgia, Tennessee and the Carolinas, out of offices in Elizabethton and Chattanooga, Tenn., and Atlanta, Ga. Cooper Engineering Company will handle Northern California from its office in San Francisco.

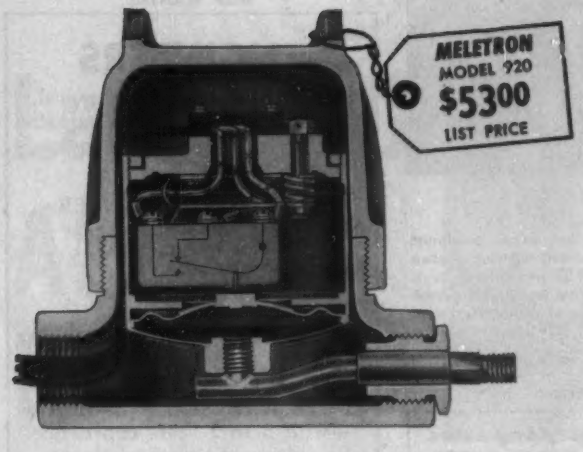
THE OKONITE CO. has appointed **Elbridge H. McNeill** regional sales manager of the newly-formed Mid-West sales region. He will supervise the Chicago, St. Louis and Rocky Mountain sales areas from the company's Chicago headquarters.

A member of the Okonite sales force since 1925, McNeill has served as Chicago district manager for the past five years. This post has been assumed by **Robert B. Zane,** formerly manager of railroad sales and, most recently, manager of utilities and industrials.

ALLIED CHEMICAL & DYE CORP. announced that **Carl O. Kingsbury** retired March 31, after 21 years as New Orleans sales branch manager for the company's Solvay Process division. Succeeding him is **Charles E. Varn.**

Kingsbury graduated from the University of Pittsburgh with a B.S. degree in petroleum engineering. He joined Solvay as a salesman at the St. Louis sales branch in 1926. He moved to the Boston sales office in 1929 and in 1937 was appointed manager of the New Orleans sales branch.

Varn received a B.S. degree in biological chemistry from Virginia Polytechnic Institute. He joined Solvay in 1947 as a chemist and three years later became a salesman at Solvay's Charlotte, N. C. sales branch.



Here's the Simplest Diaphragm Pressure Switch for Explosive Atmospheres

WE BUILD IN	WE DON'T USE
EXTREME ACCURACY and DEPENDABILITY maintained during operating life due to direct acting design	**LINKAGES & BEARINGS** which, as they wear, make the setting of the pressure switch drift.
OPERATION IN ANY POSITION which saves the installation costs encountered in mounting a switch that uses liquid switching elements.	**LIQUID SWITCHING ELEMENTS** which make the switch difficult to mount and very critical to vibration.
IMMUNITY TO VIBRATION you can mount the switch directly on your vibrating or moving equipment.	**ACCORDION DIAPHRAGMS** which make the pressure switch sensitive to vibration.

Ask for bulletins 920-925

barksdale valves

PRESSURE SWITCH DIVISION
5125 ALCOA AVENUE • LOS ANGELES 58 • CALIFORNIA

CRESCENT

POLYETHYLENE MULTITUBE

Special Types of Cabled Instrument Tubing to meet your specific need

These types employ HIGH MODULUS, high density polyethylene tubes made from new low pressure process polyethylene. Four to nineteen tubes of ¼" OD are SPIRALLY CABLED together under heavy protective coverings which are designed to meet the unusually severe installation requirements with lowest cost.

TYPE XPT-U. UNDERGROUND AND GENERAL PURPOSE TYPE

Designed for direct earth burial or use in underground conduit and for above ground where subject to moderate mechanical abuse. Tubing is protected by a thick, tough polyvinyl chloride (PVC) sheath resistant to impact, corrosion and flame.

TYPE XPT-F. FLASH FIRE RESISTANT TYPE

A thick PVC sheath, heavy asbestos braid and overall PVC sheath over the tubing assembly provides several minutes of time delay for shutdown in the event of a flash fire. This construction also gives adequate protection from welding and cutting metal splash.

TYPE XPT-FA. FLASH FIRE RESISTANT—ARMORED TYPE

For complete mechanical protection, the tubing, thick PVC sheath and heavy asbestos braid are covered by an interlocked, galvanized steel armor. Designed for dry locations, type XPT-FA also gives several minutes of time delay in the event of a flash fire.

Send for BULLETIN with complete information.

CRESCENT
INSULATED WIRE & CABLE CO.
TRENTON 5, N. J.

For more data on advertised products, use Readers' Service Cards, last page.

Petroleum Refiner Classified Ads

Petroleum Refiner New Classified Rates

RATES: Regular Classified (undisplayed) set in this type: 20 cents per word. Minimum charge, $4. Blind box address in our care counts six words. Replies forwarded without charge. Display Classified ads, set in suitably larger type with ruled border, $12.50 per column inch. Ten percent discount for two or more insertions of same copy in consecutive issues. All Classified ads payable in advance. Copy deadline: 25th of month preceding date of issue. Send copy and checks to: Classified Advertising, Petroleum Refiner, P. O. Box 2608, Houston, Texas.

* * * * * * * * * * * * * * * *

HELP WANTED

Sales Engineer Wanted

Well-established successful firm has opening in an expanding sales department for young man looking for an opportunity in sales work. Must be college graduate, not over 33, in good health and not afraid of work. Experience in refining-petrochemical industry preferred. Applicant will be trained at home office before moving into sales work on basis of salary plus commission incentive and traveling expenses. Our own sales personnel know of this advertisement. Your reply will be confidential and should be sufficiently complete to merit contacting you for an interview.

Address Box 286-R PETROLEUM REFINER Houston, Texas.

CHEMICAL and MECHANICAL ENGINEERS

A large and expanding international petroleum company has openings for several Chemical and Mechanical Engineers with outstanding ability. This is a challenging opportunity to share the responsibility of coordinating international refining operations. Excellent advancement opportunities for applicants with a minimum of 3 years petroleum or chemical industry experience. Immediate assignment to our Far East refineries or to our White Plains Headquarters with an eventual overseas assignment. Salary commensurate with experience, liberal annuity, insurance, hospitalization and savings plans. Will pay moving and transportation expense. Please send resume to:

DENNIS V. WARD
STANDARD-VACUUM OIL COMPANY
P. O. BOX 1000
WHITE PLAINS, N. Y.

■ **CHEMIST.** Have opening for Young Chemist or Chemical Engineer with one to three years experience in asphalt formulation to do development work on asphalt additives. Good opportunity in field offering broad possibilities. Excellent benefit program. Western New York location. Write complete resumé to Box 292-R, PETROLEUM REFINER, Houston, Texas.

HELP WANTED

Petroleum Refinery Engineers

Positions involve technical service and consulting type work for petroleum refiners. Requires chemical engineers with several years experience in refinery process engineering, operations, and/or economic analysis. Positions offer a wide variety of work with sales, research, refinery, and company management problems. Also affords opportunity for industry-wide contacts with refining and process companies and for using initiative and individual expression to increase responsibility. Location in Detroit suburb offers ideal professional environment with a choice of city or suburban living. Send resume to:

Personnel Manager
ETHYL CORPORATION
1600 W. 8 Mile Road
Ferndale 20, Detroit, Michigan

Refinery Process Engineer

Expanding independent refinery has opening for Technical Assistant to Refinery Manager.

Excellent opportunity for Chemical Engineer who is willing to assume responsibilities. Minimum of 5 years plant operating experience.

Work will be to assist with plant operations such as catalytic cracking, reforming, de-sulphurization, atmospheric and vacuum distillation, polymerization, asphalt, wax, etc.

All replies confidential, Box 289-R, c/o PETROLEUM REFINER, Houston, Texas.

Port Houston Manufacturing Corporation, located at 2405 Avenue K, Galena Park, Texas are interested in inquiries on ASME code pressure vessels for the oil, chemical, refining and industrial plants, also welded and large outside diameter pipe as well as oil and water casing. We are licensed to manufacture and sell Medearis Oil Well Supply Company mud mixers and shale shakers. Our rig up yard can handle up to six rigs at one time.

Write or call us at ORchard 4-7691, Houston, Texas.

POSITION WANTED

■ **Piping Designer-Draftsman,** in Brazil. Five years experience in petrochemical industry piping design, layouts, isometrics, all phases. Experience in site (construction) supervision, piping, montage, painting, testing, start-up. Familijar American Design practice, desires position US firm in the states. Salary commensurate experience. Box 291-R, PETROLEUM REFINER, Houston, Texas.

FOR SALE

Specify SAUEREISEN
ACIDPROOF CEMENTS—COMPOUNDS
FOR
Tanks, Sewers, Stacks, Floors
Technical cements for all purposes.
Send sketches or samples
Sauereisen Cements Company · Pittsburgh 15, Penna.

When you see a large chimney think of Sauereisen Cements.

HELP WANTED

ENGINEERS

Opportunities for chemical, mechanical, or metallurgacl engineers in midwestern petrochemicals plant.

INSPECTION ENGINEER—with 3 to 7 years experience in inspection work in refinery or Chemica! process plants.

Requires knowledge of corrosion, construction and heat resistant materials, equipment limitations, and codes.

MECHANICAL ENGINEERS—with 3 to 7 years experience for plant engineering departments.

Must have knowledge of various types of mechanical equipment, such as pumps, compressors, and turbines, including design, repair, installation and materials of construction.

Submit resume to Professional Employment Manager

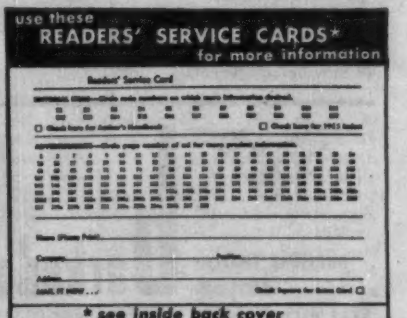
NATIONAL DISTILLERS and CHEMICAL CORP.
99 Park Avenue
New York 16, N.Y.

WANTED

We will buy your surplus stocks of brass or steel, samless condenser tubes. Mail inventory to Box 290-R, PETROLEUM REFINER, Houston, Texas, stating condition of material and asking price.

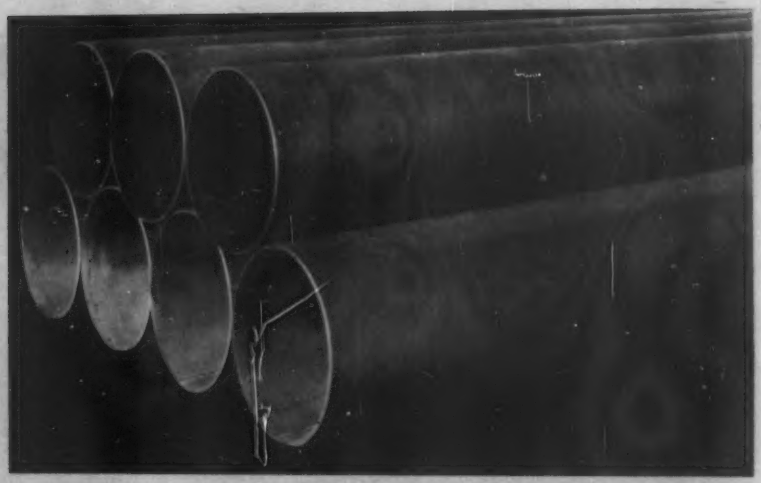
FOR SALE

use these
READERS' SERVICE CARDS*
for more information



*** see inside back cover**

Large O.D. ALLOY PIPE



fabricated to meet your requirements

For high pressure, high temperature water lines . . . for sewage outfall lines . . . for any job requiring fabricated steel pipe of 14" O.D. or larger . . . you can depend on Posey's many years of engineering and manufacturing experience and complete production facilities. Write, wire or phone for information without obligation.

POSEY IRON WORKS, Inc.

Steel Plate Division

LANCASTER, PENNSYLVANIA

New York Office: Graybar Building

TANKS • DIGESTERS • PRESSURE VESSELS • DREDGE PIPE

HOW TO SOLVE *heat transfer problems*

Here is the book to give you a quick view of heat transfer fundamentals and the calculations of applying them in the design of such equipment as feed-water heaters, condensers, boilers, internal-combustion engine cylinders, and fan coils. Emphasizes basic aspects and immediately useful calculations!

Just Published—3rd Edition

Introduction to HEAT TRANSFER

By Aubrey I. Brown and Salvatore M. Marco, both of The Ohio State University

Third Edition, 328 *pages*, 6x9, 70 *illus.*, $6.75

Engineers encountering a growing number of problems in this field will appreciate the directness of the treatment. Third edition includes new chapters on fluid flow in the convection process and graphical and numerical methods applied to heat conduction problems.

Chapter Headings

1. Modes of Heat Transfer
2. Heat Transfer by Conduction
3. Equations for the Calculation Conduction of Heat Transfer
4. Radiation
5. Fundamental Units and Dimensional Analysis
6. Fluid Flow in the Convection Process
7. Forced Convection
8. Free or Natural Convection
9. Heat Transfer to Boiling Liquids
10. Condensing Vapors
11. Over-all Transfer of Heat
12. Applications of the Principles of Heat Transfer to Design Problems
13. Transient Conduction
14. Graphical and Numerical Methods for Heat-conduction Problems

The Gulf Publishing Company

P. O. Box 2608

Houston 1, Texas

LIGHT PORTABLE TOOL BENDS 8" PIPE 90°

TAKES ONLY 3 MIN. WITH 2 HP MOTOR

ALSO USES ½ HP MOTOR OR GASOLINE MOTOR

- **EASY TO USE**—Quickly set up for pipe size and bend desired. Quick-releasing bending shoes. Bend indicator.
- **EASY TO MOVE**—Swiveling casters. Frame folds back for compact storage. Simple sections are quickly dismantled.
- **FAST and POWERFUL**—Hydraulic cylinder has 4½" bore and 60" ram travel. Pump develops up to 10,000 p.s.i.
- **SMALL and LIGHT**—By far the smallest, lightest, most economical bender available in this capacity.

SAVE UP TO 90% on piping jobs! Minimize pipe cutting and welding time . . . save cost of elbows!

You can make perfect, wrinkle-free bends . . . on the job or in the shop . . . with this low-cost hydraulic tool. Bends made cold, in just one setting. No filling.

Interchangeable parts handle ⅜" to 8" pipe, X or XX. 8" XX pipe bent 90° in only 3 min. when using 2 hp. motor. Also operates with ½ hp. motor or gasoline engine.

Write for Free Bulletin!
Learn how Tal benders can give you important savings in labor and material cost. Write today

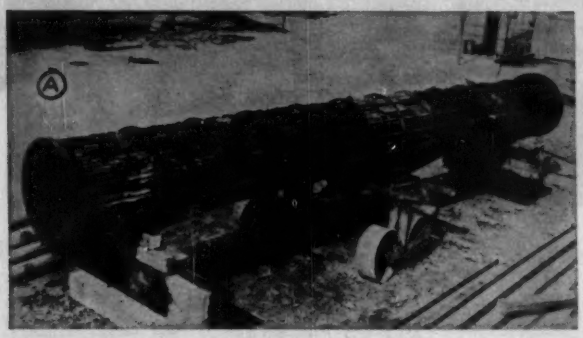
TAL BENDING EQUIPMENT, Inc.

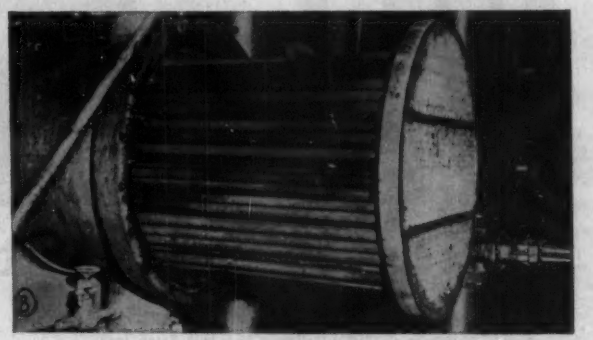
DEPT. 33

MILWAUKEE 2, WIS.

What's New in Equipment . . .

. . . and Manufacturers Literature





Before . . . . . After

Crude Conditioner Cuts Maintenance Costs

A product called Cronox C has just been developed that chemically treats the crude charge to remove causes of fouling and corrosion. Instead of providing protection against corrosive or sludging agents, the conditioner prevents their formation and eliminates them from the process stream before they have an opportunity to do damage.

The conditioning treatment removes oxygen from the crude and lowers the sulfur and mercaptan content of the crude. This action prevents the formation of fouling cokes and gums and retards the corrosive action of hydrogen sulfide in the overhead equipment.

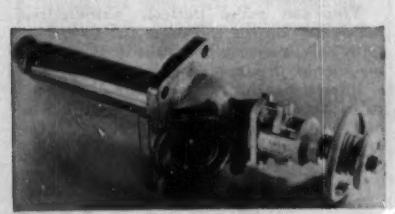
Corrosive acids such as hydrochloric and naphthenic are neutralized by the treatment. Naphthenic acids become soaps; hydrochloric acids become salt. Rendered harmless, removed from the crude unit in the bottoms, these acids cannot cause overhead corrosion.

The conditioning solution (Cronox C conditioner, soda ash and water) is fed into the crude charge continuously by a simple injection system installed at the suction end of the crude charge pump or after the desalters. The solution mixes with the crude charge flowing through the crude heater to the crude fractionating tower. Harmless reaction products leave the crude tower with the heavy bottoms.

The amount of Cronox C concentrate required is small—1 cc per barrel of crude. A typical 25-gallon conditioning solution contains 0.2-gallon Cronox C., 24.8 gallons of water and 25 pounds soda ash.

The photo showing a dirty gasoline cooler bundle indicates the serious fouling and corrosion found after nine months' service on 1 million barrels of naphthenic crude. The clean bundle is an actual turnaround inspection photo after it had been in service for 18 months processing 2 million barrels of the same crude treated with Cronox C conditioning solution. Aquaness Department, Atlas Powder Co.

Circle E1 green card, last page



Glass-Lined Valves Rinse Glassed-Steel Reactors

A new "spray-rinse" valve is currently being marketed. The new glassed-steel valve eliminates manual cleaning of glassed-steel reactors and thereby increases cycle time through reduction of downtime.

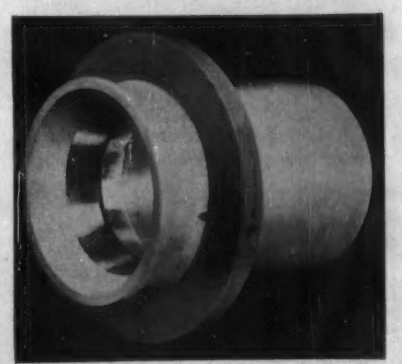
The "spray-rinse" valve was designed initially for polymerization processes to minimize build up of polyvinyl chlorides on the inner surfaces of glassed-steel reactors, but it is also well suited for other process industries where sticky residues or solids remain on the vessel walls upon completion of a batch run.

The 3-inch glass lined valve offers these features:

- Vessel interiors can be cleaned and washed down without opening the manhole.
- It does not present to the process a large area of polymer adhesive, metallic surface such as a stainless steel spray ring pipe does.
- Simple installation is easily made through conventional 3-inch nozzle openings. Larger nozzles can also be used in conjunction with reducing flanges.
- Liquid from the spray-rinse valve covers the entire inner surfaces with sufficient intensity for good washing of any reactor up to 120" diameter.
- Major portion of liquid steam is directed upward toward the dome.
- Adjustable spray pattern provides direct spray coverage for all surfaces.
- Valve replacement is easily made.

The surfaces of the spray rinse valves which are exposed to the product are of highly acid-resistant glass. The corrosion resistance of glass protects the product against contamination; and since glass exerts no catalytic effect, unwanted side reactions are eliminated. The new valve can safely handle all acids, except hydrofluoric, even to elevated temperatures and most alkali solutions. The Pfaudler Co.

Circle E2 green card, last page



Epoxy Flow Tube Meters Liquid With Low Head Loss

A compact, plastic, insert-type Dall Flow Tube, Model DFT-PI, has been announced. It is made of epoxy or polyester resins, reinforced with Fiberglas, with cor-

THE MODERN TREND IN OIL REFINERIES

HUDSON Solo-aire units pictured above operate in a large Texas Gulf Coast Refinery, in which Solo-aires are used for a complete range of refinery services, transferring 300 million BTU's per hour directly to air.

Over-all economic comparisons of HUDSON Solo-aire cooling versus water cooling for new refining units almost invariably result in selection of Solo-aire units for much or all process cooling.

In two complete 40,000 barrel sea-side refineries now being constructed abroad by one of the world's largest refiners, HUDSON Solo-aire units will be used for ALL process cooling services. NO WATER WILL BE USED FOR PROCESS COOLING.

In the United States in a 40,000 barrel refinery being built adjacent to an unlimited water supply, 50% of the total dissipated heat will be transferred directly to air through HUDSON Solo-aire units.

Operating results of HUDSON Solo-aire units installed in oil, gas and chemical plants throughout the free world have led to continuing repeat installations.

For new process installations and for replacement of high maintenance water-cooled equipment, Solo-aires offer in most cases clear-cut advantages. Let HUDSON assist you in objective analyses of air versus water cooling.

New bulletin available--

"COOLING WITH AIR IN REFINERIES AND CHEMICAL PLANTS"

HUDSON

ENGINEERING CORPORATION

FAIRVIEW STATION • HOUSTON, TEXAS

9935 Santa Monica Blvd. Beverly Hills, California • 122 East 42nd St. New York 17, N. Y. • 17 Stratton St., Picadilly London W.1, England • Corrientes 1115 Buenos Aires, Argen. • Rua Mexico 45 Rio de Janeiro, Brazil

"It is increasingly apparent that the domestic producers' responsibility to the United States goes beyond the hard, constant work needed to find and develop the supplies which our people need. In addition to making sure that there is enough of our products to meet demand, producers also have the growing obligation to hold costs down so that the prices to consumers can be kept at the lowest practical level."

—M. J. Rathbone, President, Standard Oil Company (New Jersey)

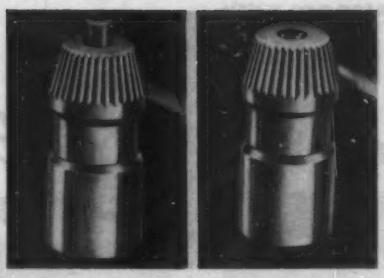
ESSO

STANDARD OIL COMPANY (NEW JERSEY)
AND AFFILIATED COMPANIES

rosion-resistant metallic throat-ring and flange. This flexible differential producer is ideally suited for metering ordinary liquids, gases, and even such "difficult" fluids as acids, alkalies, and slurries, with very low head loss and consequent reduced pumping cost.

The flow tube fits between pipe flanges, and its extremely short length and light weight make it especially easy to install. Accuracy is within ±1 percent of actual flow rate for uncalibrated units, and can be increased to ±½ perecent by laboratory calibration. Standard models are available with a variety of metallic materials, and for pH from 0.2 to 10. Temperature ranges are from —60 to 220 F. Builders-Providence, Inc., a division of B-I-F Industries, Inc.

Circle E3 green card, last page

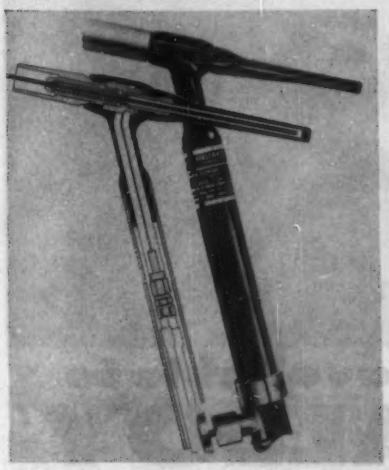


Tire Pressure Indicators Screw On The Valve Stem

Designed to save costly time both on the road and in the shop and control the serious problem of truck tire wear, a new product, No-Lo Tire Pressure Indicators, is being marketed. Precision engineered and manufactured, these inexpensive indicators, which screw on the valve stem of each tire, are actually miniature pressure gages.

Drops in air pressure are indicated automatically by the Indicators when the red tip of a pressure control rod slides back into the valve where it cannot be seen. As long as the air is at a safe level, the red rod remains visible. The driver or maintenance man need only glance at the indicator to tell whether the tire has lost too much air for safe operation.

The units are factory set for a prede-



Hand-Welding Torch Weighs Only 7 Ounces

A new Heliarc hand-welding torch, the HW-18, has cooling water passages molded in the torch head, giving complete freedom from leakage. Lighter, smaller, and more rugged, the torch body is made of Fiberglas-reinforced phenolic with exceptional heat resistance. New gas cups for the torch have improved thermal shock and heat resistance, with impact strength four times greater than usual ceramic cups. For exceptionally hard use, metal sleeved cups are available.

The new torch weighs 7 ounces. Improved design of collet bodies give more efficient argon shielding, thereby conserving gas. Optional shut-off valve on handle also conserves gas, besides saving steps and increasing efficiency. Collets, collet bodies, cups and caps are interchangeable with the Heliarc HW-17 hand-welding torch. Linde Co.

Circle E4 green card, last page

Digital Device Feeds Output to Typewriter

Catalog Sheet 32A100 describes Model 32AA2 Digi-Coder, a device which converts a shaft position representing the analog value of a variable into a coded digital output. Output can be fed into an electric typewriter, tape punch, computer, or printer. Fischer & Porter Co.

Circle E5 green card, last page

FROM CONCEPT TO TURNKEY

Surveys, economic analyses, process studies and design, mechanical engineering, procurement, construction supervision and operating assistance are among the services offered by The C. W. Nofsinger Company.

Construction may be handled by a contractor of your choice or by your own personnel. Or, through our affiliate, The Nofsinger-Long Company, we provide both design and construction, ensuring undivided responsibility from concept to completion. Our clients, past and present, will testify to our performance.

"In Engineering, it's the People that count"

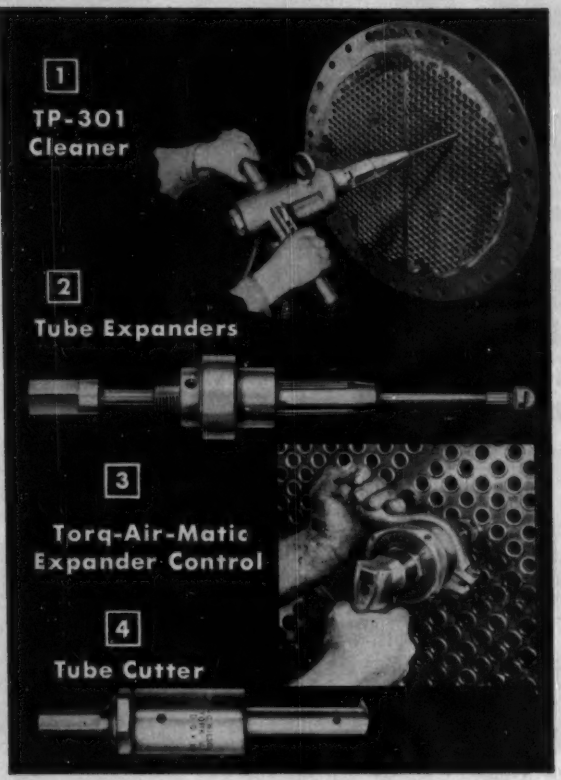
THE C. W. NOFSINGER COMPANY
Engineers and Contractors for the Petroleum and Chemical Industries
307 E. 63rd STREET KANSAS CITY 13, MISSOURI

West Coast Representative
A. R. Chandler
609 S. Grand Avenue
Los Angeles 17, California

Gulf Coast Representative
Russell G. Dressler
204 Carolwood Drive
San Antonio, Texas

Keep Heat Exchangers on stream with

WILSON
TUBE MAINTENANCE TOOLS



1 Heavy-duty TP-301 Cleaner is a positive air-driven, hollow rotary shaft, drill type tool. Tube is scavenged with air or water while cleaning.

2 Wilson Models 41 and 44 Tube Expanders incorporate an improved, adjustable ball bearing thrust collar and are designed for efficient, easy rolling and maximum roll length adjustment for various tube sheet thicknesses.

3 New Wilson Torq-Air-Matic is the first and only air-driven tube expander drive that accurately controls tube expansion by directly measuring torque output at the mandrel.

4 Wilson tube cutter is easy to use and does a fast job. Cutter sizes and shanks available to meet all heat exchanger requirements.

Write today for your copies of Wilson Tube Cleaner catalog No. 77 and Wilson Tube Expander catalog No. 88. TW-981

Representatives in principal cities

THOMAS C. WILSON, INC.
21-11 44th Ave., Long Island City 1, N. Y.
Cable address: "Tubeclean", New York

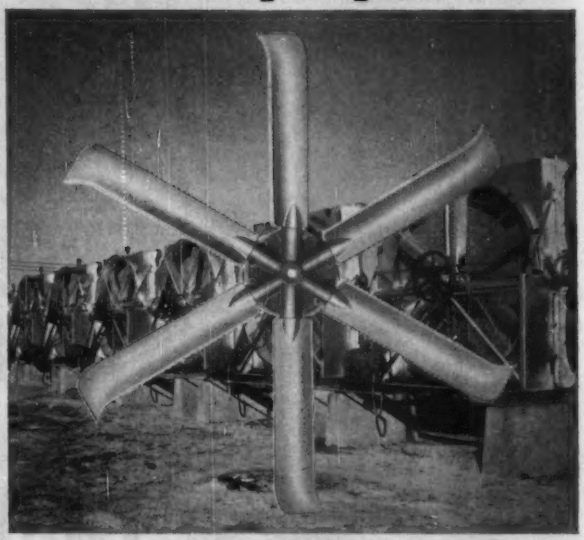
WILSON
TUBE CLEANERS • TUBE EXPANDERS

new adjustable pitch

"macheta" airfoil

Aerovent

54"–96" propellers



now available in

'T-ALLOY'

Acclaimed as *industry's most efficient air-moving* surface, Aerovent "Macheta" Airfoil Propellers are leading the way in cooling tower and heat exchanger fan design and engineering.

Latest innovation is the use of "T-ALLOY" for extra strength and additional corrosion resistance in especially rugged applications. Inherently a high-strength alloy, "T" provides better resistance to shock and vibration. This, plus *individual blade balancing* for complete interchangeability of all units and *universal pitch markings* to simplify accurate field setting, is your assurance of dependable, lasting performance in any installation.

STANDARD CONSTRUCTION ALUMINUM-ALLOY BLADES FURNISHED FOR ALL NORMAL-DUTY REQUIREMENTS

CAST ALUMINUM HUBS for light weight and ease of handling feature bolted construction for fast, easy assembly.

"POSITIVE-LOCKING" Pitch Adjustment is accomplished by keyways which hold peripheral-keyed blade shanks.

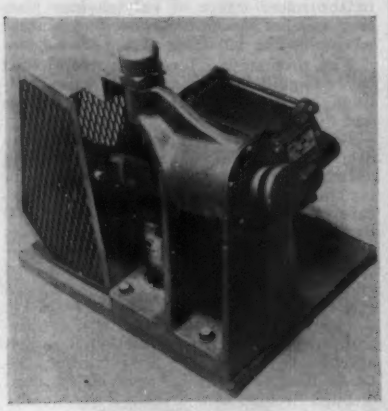
Write for free bulletin 500

Aerovent FAN COMPANY, INC.
LARGE PROPELLER DIVISION
304 Wright Bldg.
TULSA 3, OKLA.
Main Office and Factory
PIQUA, OHIO

termined air pressure based either on the recommendation of the tire manufacturer or for any setting specifically desired by the purchaser. The setting cannot be changed once released by the factory.

The units are made up in five-pound increments for truck tires (from 40-105 pounds), also are available for passenger cars in two-pound increments (from 22-34 pounds). The red rod drops back into its seat out of sight as a warning of low pressure when the air in the tire drops six or more pounds below the determined minimum. Frebank Co.

Circle E6 green card, last page



Displacement Pump Good For Wide Viscosity Range

The multi-service Series 7000 Variable Volume Electric Drive Injector, a microcontrolled positive displacement pump, is designed to pressure deliver accurately measured quantities of hot or cold compounds covering a wide viscosity range. The plunger stroke length, adjustable from 0 to 1¼ inches on a calibrated scale, can be changed and locked with the injector in operation. The injector is powered by a ¼ hp, 1750 rpm (constant) explosionproof or fully enclosed electric motor (1 or 3 phase) geared down to non-fluctuating 48 rpm. Custom prime mover application will be made according to the user's specifications. Automatic or remote control mechanisms are easly adapted.

Power is transmitted from the gear motor through a positive mechanical linkage and reciprocating arm connecting the plunger. The linkage is designed to return the plunger to full bottom position regardless of stroke length. Complete chemical displacement per cycle, plus uniform plunger and packer wear is assured by this feature. Available with either ½- or 1-inch plungers, the injector will deliver volumes ranging from .5 gallons per hour at 7000 psi to 2.5 gph at 1200 psi with the ½-inch plunger or 4.4 gph at 750 psi to 12.75 gph at atmospheric pressure with the 1-inch plunger.

Check valves are not an integral part of the cyclinder and can be removed for cleaning or replacement. Complete cylinder assemblies can be exchanged or replaced without pump disassembly. The variable volume electric drive injector is designed with a maximum over-all safety factor, thus assuring uninterrupted, safe, economical operation even under adverse conditions. Texsteam Corp.

Circle E7 green card, last page

New Wrought Iron Superior In Corrosion Resistance

A significant development in the history of wrought iron metallurgy (new 4-D wrought iron) has just been announced.

Seventeen year in-service and laboratory tests have been conducted to compare 4-D wrought iron not only with standard wrought iron, but with a number of other metals. Results of these tests indicate that 4-D wrought iron has greatly superior resistance against many kinds of corrosive forces including those caused by severe industrial atmospheres, acid solutions, salt water, and steam condensates. A. M. Byers Co.

Circle E8 green card, last page

New Equipment . . .

Reflective Type Insulation Effective to Plus 2,000 F.

The introduction of prefabricated thermal insulation changes all previous concepts. It is an all-metal reflective insulation, utilizing an entirely different approach to the problem of controlling operating temperatures, and of minimizing heat losses. This unique product is sold under the trade name, Mirror Insulation.

Literally "done with mirrors," this insulation utilizes a reflective principle which has long been employed in the well known

EQUIPMENT with Engineering SERVICE

METER RUNS

MECO Standard Meter Runs conforming to A.G.A. specifications are made in our own fabricating shop of materials carried in stock. —Seamless steel pipe, Tube Turn welding fittings, Forged steel flanges, and Commercial Orifice fittings. Meter Runs are available bored and honed, coated bore for corrosive service, and to special designs.

Ask for Bulletin No. P-100

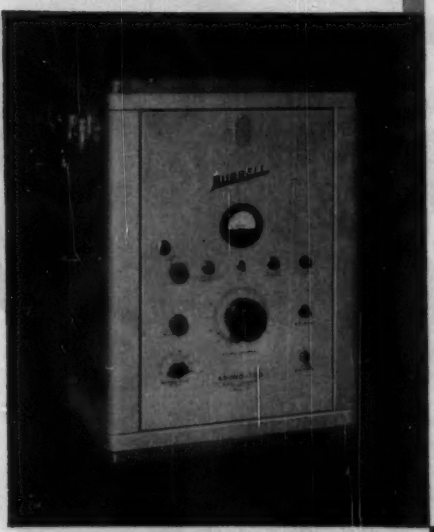
MECO MAINTENANCE Mechanical CORPORATION

BURRELL "For Scientists Everywhere"

THE KROMO-TOG®

MODEL K-3

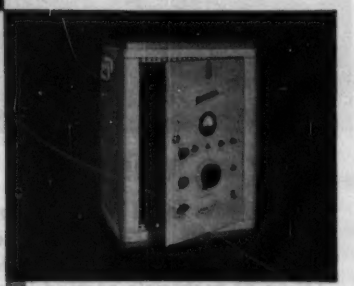
for gas and vapor chromatography



The Kromo-Tog, Model K-3, is a compact, low-cost, chromatographic instrument for the speedy routine analyses of most gases and liquids of any boiling point to 370° C., and over.

Accessories may be added to the basic "build-up" unit. Panel-door and sides open for free access to all components. Extremely easy to install and use, this model may be bench or panel-mounted anywhere.

- SEPARATE COLUMN TEMPERATURE CONTROL
- ACCESSIBLE COLUMNS FOR RAPID CHANGE
- HIGH SENSITIVITY OF DETECTOR CELL
- FRACTIONS AND CUTS EASILY COLLECTED



THE BURRELL KROMO-TOG

Model K-3

Basic chromatographic unit,
less recorder or power source for cell.
Operates at 115 volts, 60 cycles.

Burrell Cat. No. 340-31.....$795.
F.O.B. Pittsburgh, Pa.

COMPACT SIZE
Only 24" x 16" x 13"

BUILD-UP DESIGN
Accessories can be added.

Ask for Bulletin 831

BURRELL CORPORATION

Scientific Instruments and Laboratory Supplies

2223 FIFTH AVENUE, PITTSBURGH 19, PA.

New Equipment . . .

Thermos bottle. The insulation can be constructed to handle industrial temperatures in the range of minus 400 F. to plus 2,000 F.

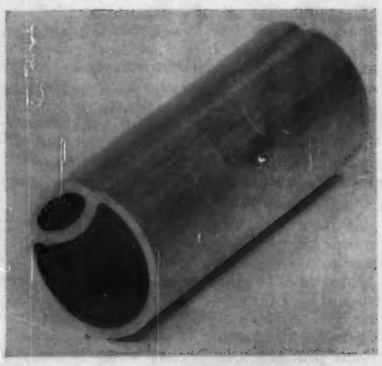
Owing to its extremely broad temperature limits, this new product can be employed for both single and dual-temperature service applications heretofore too severe for most conventional insulating materials. Reflective insulating units have already demonstrated unusual advantages in high temperature applications such as in the manufacture of polyethylene plastics, and for the extreme low temperature service in the handling of liquefied gases.

The product is offered in prefabricated easy-to-handle units for pipes, valves, fittings, vessels, equipment, boiler casings and ducts.

Because of low cost and good heat reflective properties, aluminum alloys are normally used for the majority of components in this insulation for a temperature range of minus 100 F. to plus 1,000 F. However, where extreme temperatures are involved or special conditions warrant, use is made of stainless steels and other high grade alloys with excellent results.

The product, as furnished, has an integral outer case of heavy gage metal which provides durability and attractive appearance. Ruggedness is further achieved through welded and riveted construction. Other plus features of the product, accruing from all-metal construction, are: non-absorbent, sanitary, readily cleansed, adaptable to easy removal and replacement without damage, and unaffected by vibration and thermal shock. Mirror Insulation Co.

Circle E9 green card, last page



Duplex Aluminum Pipe Carries Steam and Product

Aluminum duplex pipe is being produced. The tubular product is extruded in four sizes—1½, 2, 3, and 4 inches. It is made in standard 30-foot lengths, and can be ordered in non-standard lengths from 3 feet to 40 feet. The pipe is available in alloy 3003F or 6063T5.

Duplex pipe, carrying steam in one line and process liquid in the other, is used in many applications in the chemical, petroleum refining, and petrochemical industries. The primary application is in handling of liquids which tend to solidify or become viscous upon cooling.

A brochure detailing suggested methods

New Equipment . . .

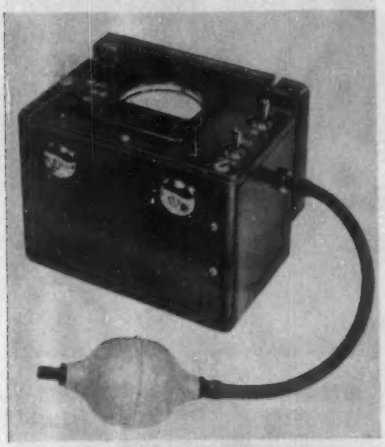
of joining the duplex piping and providing other technical data is available. Reynolds Metals Co.

Circle E10 green card, last page

Flexible, Braided Heaters Normalize Welds at 1470 F.

New electrical armored heaters operating at temperatures of 840 F. and 1,470 F. are described in four-page bulletin that gives data on uses with metal vessels, pipes and construction. Arthur S. LaPine & Co.

Circle E11 green card, last page



Portable Indicator Checks Air for Explosion Hazard

A Portable Oxygen Indicator for checking oxygen deficiency or conditions in an atmosphere that might increase fire and explosion hazards has been developed. It measures the percent of oxygen throughout a range of 0 to 25 percent oxygen content by volume with an accuracy of ±½ percent. The meter scale is following a square root function and has the 5 percent graduation near the center.

Oxygen is measured by a detector cell in which a gas or atmosphere to be analyzed is circulated through a hollow carbon electrode. The carbon electrode and a zinc electrode are supported in a small Lucite container filled with a special electrolyte called Oxylite. Oxygen diffuses through the porous carbon and combines with hydrogen ions which have been brought to the electrode by electric current produced by the detector cell. The hydrogen ions polarize the cell, i.e., produce an opposing electromotive force. This is counteracted by the oxygen which acts to depolarize the cell, thus changing the terminal voltage and meter reading according to the amount of oxygen present in a gas or atmosphere. A small dry cell supplies the very little current required for adjustment and standardization.

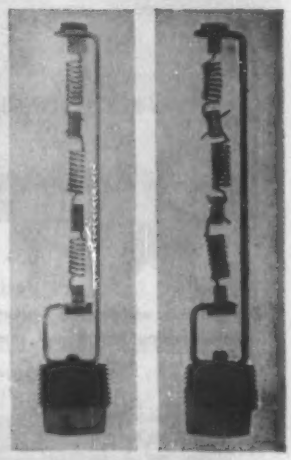
The entire instrument is enclosed in a case only 6¾ x 4⅛ x 5¾ inches and weighs only 5¼ pounds complete with sampling line. Leather waist and neck straps are provided with the instruments. Sampling lines and probes of different

BIRD-ARCHER Amine Treatment
INSURES LONGER LIFE FOR PIPE

Return line corrosion is one of the most critical problems in maintaining economical, efficient power plant operation.

Bird-Archer Amine Treatment is an easy, effective and economical way to eliminate corrosion troubles. Amines raise the pH value of the return condensate to the point whereby the corrosion potential is negative. In addition, amines provide a surface protection for the metal itself which further inhibits corrosion. In scores of plants, Bird-Archer Amine Treatment is paying a profit on its cost through savings in piping replacement and maintenance work.

To demonstrate what corrosion can do in steam and condensate return lines, we show here "before" and "after" unretouched photographs of NDHA Corrosion Testers. This is a test* developed by the American Society for Testing Materials in cooperation with the National District Heating Association. Bird-Archer supplies and analyzes these testers. Photo at left shows a Tester before installation. Photo at right shows a Tester after it had been installed for 60 days in the return line. (*Standard Method of Corrosivity Test of Industrial Water, NDHA Method, ASTM Designation 935-49.)



Write for BULLETIN CP-100 AND THE NAME OF THE BIRD-ARCHER SERVICE ENGINEER NEAREST YOU.

Send for Catalog on Bird-Archer Proportioning Pumps

BA 602R

LABORATORIES ENGINEERS • CHEMISTS

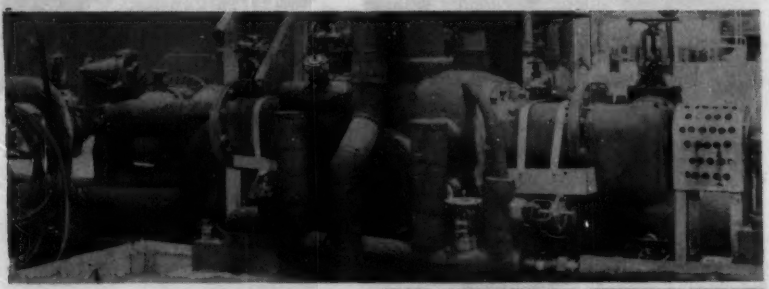
BIRD-ARCHER
WATER TREATING ENGINEERS
THE BIRD-ARCHER COMPANY, 4337 N. AMERICAN ST., PHILADELPHIA 40, PA.
New York, Chicago
The Bird-Archer Co. of California, 415 Brannan St., San Francisco 5
Offices also in Canada and Mexico

For more data on advertised products, use Readers' Service Cards, last page.

For ASPHALT PUMPING

--your best buy is

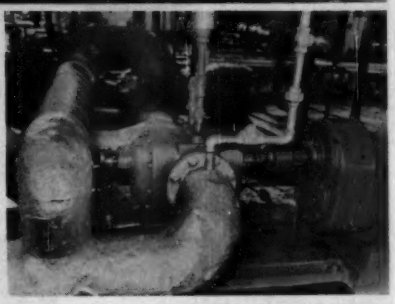
Sier-Bath ROTARY PUMPS



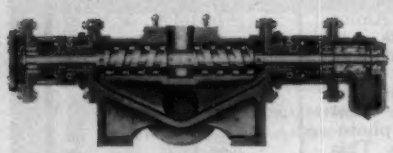
Above: Sier-Bath Screw Pump with steam-jacketed body, pumping asphalt with a viscosity of 25,000 SSU at 250°F. at 200 psi.

•

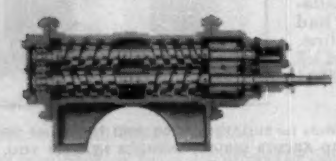
Right: Sier-Bath Gearex Pump with steam-jacketed body provides a capacity of 400 gpm. in continuous pumping of asphalt with a viscosity of 1,500 SSU at 300° F.



Sier-Bath SCREW PUMPS



External Gear and Bearing Bracket Type for non-lubricating liquids and semi-liquids



Internal Gear and Bearing Type for lubricating liquids and semi-liquids

Sier-Bath Screw Pumps maintain high volumetric efficiency because "Dual-Controlled" precision rotor design prevents rotor-to-rotor or rotor-to-casing contact—provides a continuous flow without pulsation, hammering or vibration . . . without strains, misalignment and wear on rotors, shafts, bearings and gears.

Result: Dependable, uninterrupted pumping service—less maintenance—easier servicing—longer pump life—lower overall pumping costs.

Capacities from 1 to 2,000 gpm.; viscosities from 32 SSU to 1,000,000 SSU.; discharge to 1,000 psi. for viscous liquids, 200 psi. for water and light oils. Horizontal or vertical construction. Corrosion resistant alloys, special bodies, stuffing boxes and bearings for special needs. See "Yellow Pages" for your Sier-Bath representative or write Sier-Bath Gear & Pump Co., Inc., 9261 Hudson Blvd., North Bergen, N. J.

Sier-Bath ROTARY PUMPS

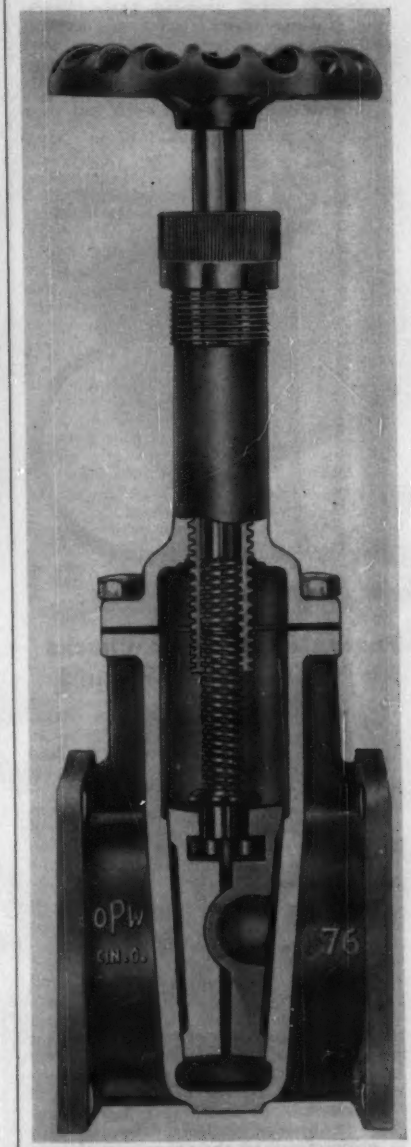
Screw Pumps | Gearex® Pumps | Hydrex® Pumps

Founded 1905 | Mfrs. of Precision Gears, Rotary Pumps, Flexible Gear Couplings | Member A.G.M.A.

New Equipment . . .

length and type are available. A line trap assembly is available for collecting condensed water or filled with Acid Gasorbent for sample atmospheres containing acid products such as hydrogen sulfide or sulfur dioxide. Mine Safety Appliances Co.

Circle E12 green card, last page



Aluminum Gate Valve Has Nylon Seating Discs

The No. 76 Gate Valve features 125 psi aluminum body and nylon seating discs. Weight is only 40 percent that of a conventional all-bronze gate valve. The resilient, but tough nylon discs afford exceptionally tight, lasting shutoff, even in presence of dirt or grit. It has broad corrosion resistance qualities. Absence of

dissimilar metals eliminates the possibility of electrolytic corrosion. Seat rings are unnecessary, thus eliminating a potential maintenance problem. Available now in 3-inch screwed end size. Other sizes to be available. Jordan Industrial Sales Division of OPW Corp.

Circle E13 green card, last page

Magnet Encased in Plastic Used for Remote Stirring

A corrosion resistant, non-contaminating remote stirrer, suitable for laboratory, pilot plant and industrial use, is available. It consists of a Teflon encapsulated Alnico V magnet which is placed into a flask or a vessel containing material to be agitated and used in conjunction with a standard commercial magnetic stirrer. The resulting reaction of the encapsulated magnet stirs the solution at a constant and controlled speed.

The encapsulated stirrers may be used in either closed or open systems, and the stirring units may be set up to provide for automatic and unattended agitation of highly corrosive liquids, saving labor and reducing hazards attendant to manual agitation. The Teflon cover of the Alnico V magnet is impervious to acids, caustics, alkalis, solvents and other chemicals except molten alkali metals, and is capable of withstanding temperatures of 110 to 500 F. The product being stirred will not build up on the Teflon covering since the Teflon itself is non-adhesive. The tough, resilient Teflon envelope will not crack or chip nor will it damage the vessel in which it is contained. The United States Gasket Co., Plastics Division of The Garlock Packing Co.

Circle E14 green card, last page

Piping Specifications Summarized in Bulletin

Those concerned with the design, testing or installation of piping systems will be interested in a 48-page bulletin just published. This bulletin summarizes and cor-

Laykold® WEATHERCOAT
protects exposed insulation

INSULATION on towers, tanks and exchangers must be kept DRY. If moisture gets through, the efficiency drops.

Modern refinery and plant design places many major insulated vessels "in the open." You can maintain the efficiency of your insulation with easy-to-apply Laykold Weathercoat.

Weathercoat is a fibrated asphalt-base material of easy troweling consistency that dries to a black, remarkably tough and tenacious coating. A majority of the leading refineries are regular users of Weathercoat.

A new product: Mastic Weathercoat, a bodied material, for use wherever economy demands the application of a *single*, thick layer.

Write today for free illustrated brochure, entitled "Laykold Weathercoat for Insulation Protection."

American Bitumuls & Asphalt Company

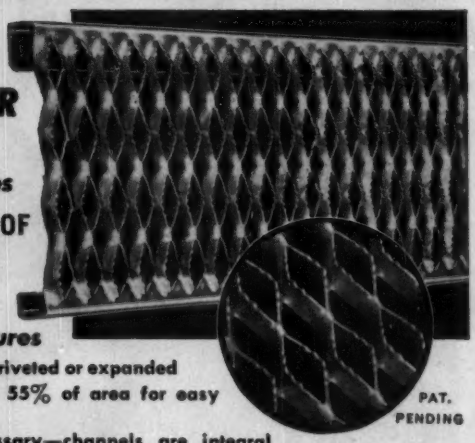
320 Market St., San Francisco 20, California
Baltimore 3, Md. · St. Louis 17, Mo. · Perth Amboy, N. J.
Mobile, Ala. · San Juan 23, P.R. · Cincinnati 38, Ohio
Inglewood, Calif. · Oakland 1, Calif. · Tucson, Ariz.
Portland 7, Ore.

For more data on advertised products, use Readers' Service Cards, last page.

two superior open steel
FLOOR GRATINGS
BY GLOBE

1 Safety GRIP-STRUT®

FOR MAXIMUM SAFETY ALL OVER YOUR PLANT



Important Safety Features

★ FIRE PROOF ★ SLIP PROOF
★ MAXIMUM STRENGTH
★ MINIMUM WEIGHT

Important Economy Features

★ All one piece, not welded, riveted or expanded
★ Open space in excess of 55% of area for easy access of light and air
★ No extra supports necessary—channels are integral part of the material. ★ Self cleaning
★ Cut and installed like lumber by your own maintenance force. ★ Low in original cost. ★ For balconies, no secondary sprinkler heads needed

Ideal for work platforms, stair and ladder steps, flooring, balconies, catwalks, machinery guards, fire escapes and for original equipment safety treads.

2 GOLD NUGGET® WELDED grating PAT. PENDING

The QUALITY GRATING for Heavy Duty Applications

★ ¾" projection weld nugget for greater rigidity and strength
★ Vertical alignment of the main load bar assured
★ All bars are load carrying bars including secondary bars
★ Anti-skid pattern

PROJECTION WELD

Each secondary load bar (A), as projected welded to the primary load bar (B) has a shear strength of 5,000 pounds per weld. There are 28 such projection welds to a square foot of grating. This means that GOLD NUGGET Welded Grating can sustain greater shock loads than other gratings.

For the complete details of these revolutionary new gratings, write for new catalogs today. Distributors in all principal cities. Consult the yellow pages in your phone book under "GRATING".

108

PRODUCTS DIVISION
The GLOBE Company
MANUFACTURERS SINCE 1914
4008 SOUTH PRINCETON AVENUE • CHICAGO 9, ILLINOIS

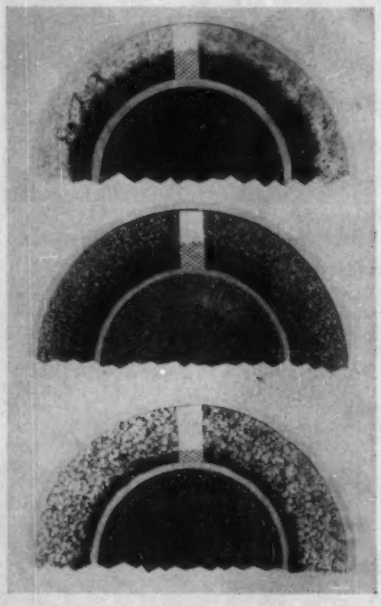
New Equipment...

relates the various specifications of the ASA Code for Pressure Piping, B31.1 and B31.1.8—1955, and the ASME Boiler and Pressure Vessel Code (Section I, Power Boilers, 1952 and Section VIII, Unfired Pressure Vessels, 1956). It is an aid in computing the minimum safety requirements for the designing of a pressure piping system.

The bulletin's extensive tabular matter makes possible a simple mathematical procedure in determining the requirements for (1) minimum wall or maximum pressure, (2) minimum pressure-stress ratios, (3) maximum allowable working pressure, (4) maximum allowable stress and (5) nominal wall thickness.

Published for Piping Engineers, the bulletin is designed to eliminate most of the tedious and time-consuming arithmetical procedures usually involved in computations of this nature. The Babcock & Wilcox Co.

Circle E15 green card, last page



Gasket Completely Seals Flange at Low Pressure

Development of a cork gasketing material designed to eliminate seepage and leakage of liquids and gases in applications where neither cork composition nor cork-and-rubber have been completely satisfactory is available.

The new gasketing material, Uniphase Cork, offers the optimum combination of impermeability, conformability and chemical inertness.

These photographs of an oil penetration test taken through a glass flange show how newly developed Uniphase cork compares with cork composition and cork-and-rubber gasket materials in resisting fluids under heat and pressure. At top, fluid has penetrated more than halfway across cork composition gasket. Middle photograph shows penetration of fluid about one-third across cork-and-rubber gasket. At bottom, Uniphase cork blocks flow of

fluid practically at inside perimeter of the gasket.

Uniphase Cork seals over a wider range of flange pressures than any other gasket material. It seals perfectly at flange pressures as low as 100 psi, a reduction of 75 percent from pressures usually required by cork compositions, and less than the pressure required by most cork-and-rubber materials. Flange loads as high as 4,000 psi will not crush Uniphase or cause it to extrude.

It seals at very low flange pressures because the elastomeric binder actually conforms directly to the flange surface, completely filling surface imperfections, and the manufacturing process retains to a high degree the natural conformability of cellular cork. Armstrong Cork Co.

Circle E16 green card, last page

Brochure Tells of Valve's Vapor-Tight Seal

A new full color four page brochure explaining the revolutionary operating principle of a steel valve, the Keroseal, is now available.

The valve is a full opening, double block and bleed, non-lubricated, optional flow valve which offers a vapor-tight seal. It is designed to handle vapor and liquid petroleum products and petrochemical fluids.

Various applications and featured advantages of installation are covered by the brochure. Materials and specifications, plus a number of illustrations and schematic drawings stressing the Keroseal's unique design and new concept of operation are also offered in this informative folder. Kerotest Manufacturing Co.

Circle E17 green card, last page

Additive Stops Sludge In Fuel Oil Storage

Formation of filter-clogging, nozzle-fouling sludge in fuel oils during normal storage periods can be reduced to harmless levels with small amounts of a special chemical.

The product, now being marketed as Fuel Oil Additive No. 2, is particularly useful in improving the stability of fuel oils made up of straight-run distillates and cat-cracked components. Blends of the latter two often result in formation of troublesome sludge, sometimes in amounts far greater than would be expected from either component alone or even the average of the two.

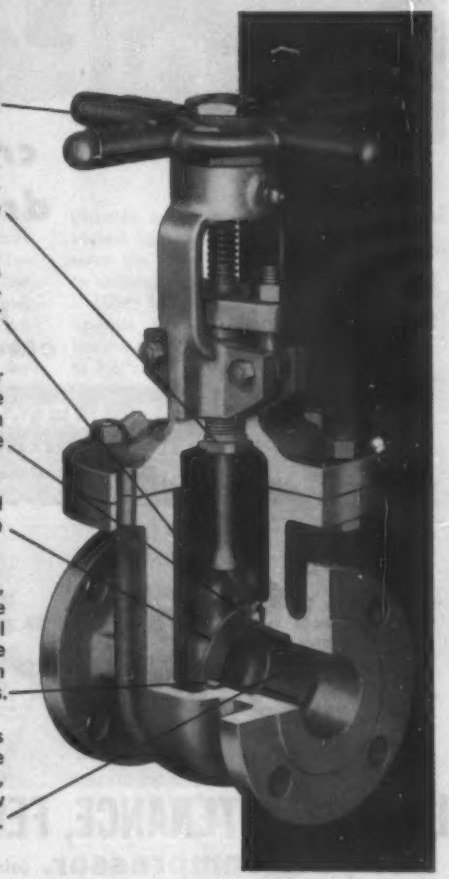
For example, engineers cited improvements in a fuel oil made up of 40 percent catalytically cracked stock and 60 percent straight run product. Storage tests showed the blend developed an insoluble residue content of 10 milligrams per 100 milliliters at the end of nine weeks and 14.5 mg. per 100 ml. at the end of 12 weeks. Addition of Fuel Oil Additive No. 2 at the rate of 17 pounds per 1,000 barrels of oil held the concentration of insoluble residue to 2.6 mg. per 100 ml. during the same 12-week period, at storage test temperatures of 110 F.

In another case at DuPont power plant, addition of $20 worth of the additive to a 50,000-gallon residual fuel oil tank eliminated a 6-inch accumulation of

Two-Way-Sealing Hamer *Leakproof* Gate Valves

ASSURE POSITIVE SHUT-OFF

UPSTREAM AND DOWNSTREAM!


Tiller-type handwheels afford plenty of leverage and make it easy to open or close valves.
Machined shoulder on stem seats against back seat bushing in the bonnet. Permits repacking of valve while valve is in open position.
Close-fitting wedge guides are carefully machined, minimizing chatter or wear caused by line pulsation.
Teflon* seals, well-known for their insert qualities, squeeze tight against wedge and with metal-to-metal fit, provide doubly effective line seal.
Hardened, precision ground wedge seating surfaces mean positive fit against seat.
Stainless steel locking rings, impervious to corrosive liquids, confine and control Teflon* seal rings to reduce expansion and contraction due to changing temperatures.
Welded stainless steel seats spell end to thread leakage common in many gate valves, permit installation of new seats with minimum effort.

You can count on absolute leakproof line shut-off when you install Hamer Leakproof Gate Valves...because Hamer Leakproof Gate Valves incorporate double sealing action—metal-to-metal fit of the wedge plus two Teflon seals. *Positive* shut-off, both upstream and downstream, saves the cost of double block and bleed installations required in many gate valve installations. Hamer Valves save money too because they last longer and require less maintenance.

If yours is a valve problem, regardless of type or application, it will pay you to call on Hamer for help.

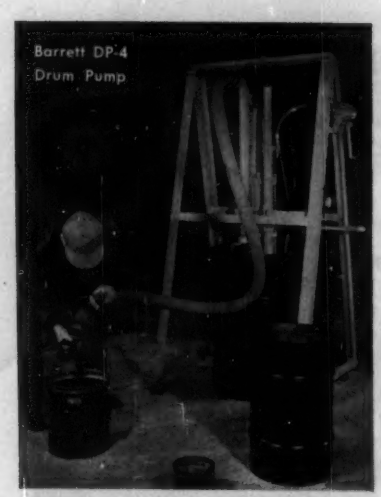
Send for FREE, illustrated catalog.

Hamer VALVES, INC.

P. O. BOX 1851 • 2919 GARDENIA AVE., LONG BEACH 1, CALIFORNIA

*Reg. T. M. DuPont 58-2

Representatives throughout the World


Barrett DP-4
Drum Pump

Barrett Crimping Head

BARRETT

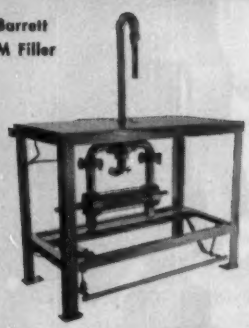
filling, crimping and drum pumping machinery

for greases and other viscous products

Send for literature.

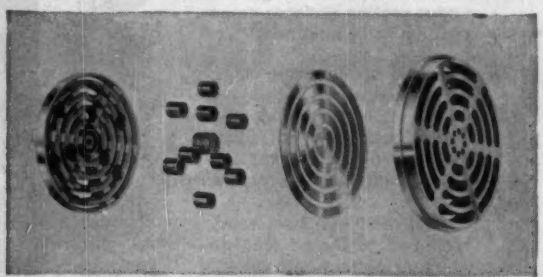
BARRETT *Manufacturing Co.*
P. O. Box 8096 Houston 4, Texas

Barrett
LM Filler



VOSS VALVES

in your machine mean



LESS MAINTENANCE, FEWER SHUTDOWNS

for your compressor. (air, gas, ammonia)

- up to 40% more valve area • minimum pressure loss • higher efficiency
- less power consumption • normal discharge temperature
- quiet, vibration-free • utmost safety • lower operating costs

VOSS VALVES are made to specification, machined from solid stock (not cast) — VALVES and PLATES are of heat-treated alloy or stainless steel; PLATES are machined, not stamped, and ground for precise close-tolerance fit; are dimensionally stable . . . ductile . . . resist fracture, high temperatures and corrosion . . . withstand fatigue. SPRINGS, of heavy rectangular sections and large diameters, add to dependability and safety.

Our detailed proposal will be sent without obligation. Send name, bore, stroke and speed of machine.

J. H. H. VOSS VALVES REG. U.S. PAT. OFF.

J. H. H. VOSS Co., Inc.
785 East 144th Street, New York 54, N. Y.

New Equipment . . .

sludge in one week of operation with no equipment downtime. Savings in mechanical de-sludging and cleaning costs alone amounted to $800.

The insoluble residues which separate from fuel oils are mostly resins and sludges which form during storage because of reaction of unstable components with each other and with oxygen. The reaction products, they pointed out, may be soluble enough in the fuel in which they are formed so that the fuel will give little trouble in use. These reaction products, however, may be insoluble in another fuel of a different type and mixing the two fuels, therefore, can cause separation of enough sludge to clog filters and foul burner nozzles. E. I. duPont de Nemours & Co.

Circle E18 green card, last page

Putty-Like Packing Molds To Stuffing Box Contours

Fluoropack, a non-gelling, putty-like packing material which is moldable under pressure to the contour of any stuffing box, is available. It was designed for use on high-speed shafts as a seal which must retain corrosive liquids without leakage, heat build-up or shaft scoring. In more than 12 months of testing, it has performed well, even with worn and out-of-round shafts. It is self-lubricating, requiring no external lubrication.

Fluoropack is composed of finely divided Teflon compounded with a blend of special fractions of polychlorotrifluroethylene

Tear Sheets—Reprints

Handling costs compel Gulf Publishing Company to make a charge of 25 cents per article for all TEAR SHEETS ordered. Such tear sheets will be sent, when available, if cash (or company requisitions) is sent with the order.

Small, individual orders for REPRINTS of articles will carry a 50-cent charge per copy WHEN AVAILABLE. Cash (or company requisitions) must also accompany these orders. The $1. price on some of our larger reprints will, of course, continue to apply.

These price rules do not affect quantity orders (starting at 100 copies) of any article printed. Prices for these will be quoted upon request.

Address: Reprints,
Petroleum Refiner,
Box 2608
Houston 1, Texas

New Equipment . . .

oil. While it contains a large proportion of the chemically inert oil, the packing will not bleed except under elevated temperatures and pressures. Its normal service temperature range is —40 F. to 350 F., but it can be used up to 450 F. where pressures are low. Halocarbon Products Corp.

Circle E19 green card, last page

No Leakage When Metering With Pulse Generators

Application Engineering Data Sheet E-57-2 describes the use of pulse generators to recirculate gases for reforming and hydrogenation processes in multi-purpose pilot plants.

The four-page sheet explains how the pulse generators accurately meter and recycle light gases without leakage, thus avoiding inaccuracies in pilot plant flow rates. When pilot plant operations are expanded to full scale, these small inaccuracies become costly errors. In this application, the pulse generator strokes a liquid piston which, while pumping and metering the gas, acts as a seal and prevents leakage.

Other information includes complete specifications, ranges, handy reference charts, diagrams and illustrations. Milton Roy Co.

Circle E20 green card, last page

Dry Chemical Extinguisher Snuffs Oil Fire in 20 Sec.

In a demonstration against a series of oil and gasoline fires, a Houston manufacturing firm has unveiled a dry chemical fire extinguisher than can snuff out a roaring fire in seconds.

The most dramatic demonstration of its effectiveness was against a roaring blaze set in a trench 80 feet long and 12 feet wide, filled with fuel oil and gasoline. With nearly 1,000 square feet of burning surface sending flames 100 feet high, a plant superintendent used the 200-pound Fire King model to smother the fire in less than 30 seconds.

Illustrating Fire King's effectiveness against building fires, a double-walled building 14 feet long by eight feet wide was soaked with gasoline and oil and

REFRACTORY HAYDITE

Makes Higher Heat Resistant Concrete

Haydite aggregate used with Lumnite cement produces refractory concrete suitable for sustained temperatures up to 1800-2000° F., which makes it excellent for tubular heaters, ducts, flues, stacks and catalytic crackers. Weighing from 30 to 40 per cent less than ordinary aggregate concrete, Haydite is exceedingly strong. It has excellent insulating properties and withstands pressures of up to 1130 pounds per square inch. Write today for free folder and complete information about Carter-Waters Refractory Haydite.
We sell direct to you.

CONSTRUCTION MATERIALS
CARTER-WATERS
KANSAS CITY MISSOURI
2440 Pasaway Phone GRand 1-2570

SHUTS OFF—but TIGHT

Proved on gas and steam lines, as well as on lines carrying heavy or viscous liquids, this valve easily closes TIGHT—with absolutely NO LEAKAGE—and just as easily opens for full, unobstructed flow.

After the lever lowers the gate into the closed position, plastic lubricant is forced by means of a screw down through the channels so that the faces of the gate are sealed tight against the valve body. To open the valve, the screw is backed off to relieve lubricant pressure.

That's all. It's rugged, simple, easy to operate, practically fool-proof in even the toughest service. Available in pipe sizes to 2½"; larger sizes available soon.

W. S. ROCKWELL COMPANY
2368 ELIOT STREET • FAIRFIELD, CONN.
Sales Representatives in Principal Cities

Quoth Sir Galva-Knight:

"NEVER GIVE RUST A START!"

Give it even a tiny chink, and rust can quickly ravage steel structures or equipment. Only *hot-dip galvanizing* can seal up every nook and cranny, inside and out, with an armor-tough coating of zinc, actually alloyed with the steel. To stop rust before it starts, specify hot-dip galvanizing by the Nowery J. Smith Company, the South's largest commercial galvanizers.

Nowery J. Smith COMPANY

Commercial Galvanizing
Pickling, Oiling, Metallizing, Sandblasting, Prime coating, and/or painting.

8000 Hempstead Hwy. UNderwood 9-1425
P. O. Box 7398 Houston 8, Texas

one of the SMITH FOUNDRIES serving the Southwest

Here is the capacity range of Purolator lube grease filters...

ELEMENT SPACING	MICRON EQUIVALENT	CAPACITIES IN GPM VISCOSITIES IN SSU WATER 30	100	300	700	1000	3000
.001	25	53	31	18	12	10	6
.0015	37.5	76	44	26	17	14	8
.002	50	97	56	33	21	18	11
.003	75	133	77	46	29	25	14
.005	125	190	110	65	42	36	21
.007	175	194	112	66	43	37	21
.008	200	207	120	71	46	39	23
.010	250	230	133	79	51	44	25
.015	375	230	133	79	51	44	25
.020	500	200	116	68	44	38	21

NOTE: Flow rates are based on clean fluid at 1 PSI initial pressure drop. To approximate the flow of 1 PSI in SCFM for air, nitrogen, or similar gases, multiply the flow in GPM at 100 SSU by 4.

. . . and here are the advantages:

- It's easier to change the Purolator element between batches. Handles are attached to the specially constructed screw-on case.
- Cleaning the element is fast, easy and thorough; simply rotate the element, manually or mechanically, against a fixed knife blade.
- Filtration is dependable and accurate because this filter uses Purolator's Metal Edge principle, a tight durable coil of precisely spaced metal ribbon.
- The filter is designed specifically for batch filtration of greases.

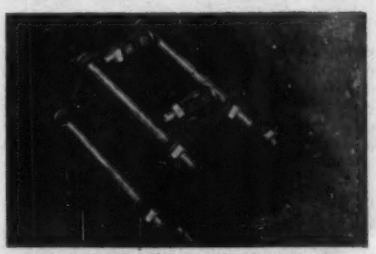
For more specific information contact Purolator Products, Inc.

Filtration For Every Known Fluid

PUROLATOR
PRODUCTS, INC.
RAHWAY, NEW JERSEY AND TORONTO, ONTARIO, CANADA

REPAIR LEAKS
QUICKLY—PERMANENTLY

SKINNER-SEAL PIPE JOINT CLAMPS stop leaks at joints. Put on under pressure—without interruption of service. Quick, simple, lasting repair. Sizes 1/2" to 24" incl. in stock.

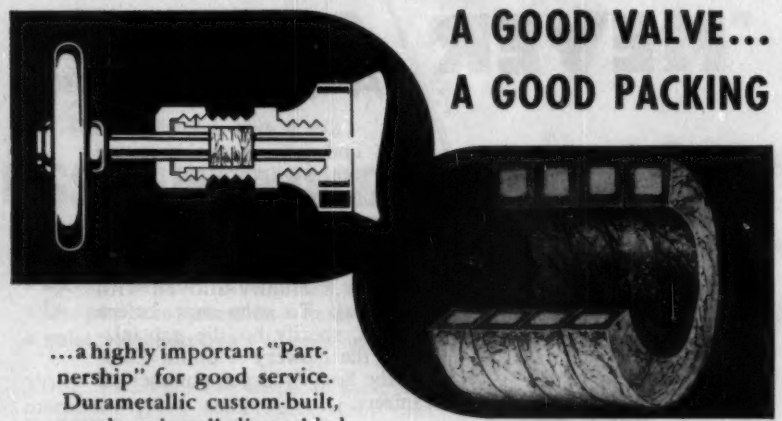


SKINNER-SEAL COLLAR LEAK CLAMP—designed to stop every type of collar leak in oil and gas lines. Sizes: 2" to 13" inclusive.

M. B. SKINNER COMPANY
SOUTH BEND 21, INDIANA, U. S. A.

They go together...

A GOOD VALVE...
A GOOD PACKING



...a highly important "Partnership" for good service. Durametallic custom-built, ready-to-install, die-molded sets of packing can be supplied in the right type and selection of materials to meet your valve sealing requirements.

In use by leading manufacturers...
We are proud to serve such well-known valve makers as Chapman, Crane, Edwards, Pacific, Stockam and Vogt. We'd like to serve you too.

The PERFECT SEAL

DURAMETALLIC CORPORATION
KALAMAZOO MICHIGAN

Tear Sheets—Reprints

Handling costs compel Gulf Publishing Company to make a charge of 25 cents per article for all TEAR SHEETS ordered. Such tear sheets will be sent, when available, if cash (or company requisitions) is sent with the order.

Small, individual orders for REPRINTS of articles will carry a 50-cent charge per copy WHEN AVAILABLE. Cash (or company requisitions) must also accompany these orders. The $1. price on some of our larger reprints will, of course, continue to apply.

These price rules do not affect quantity orders (starting at 100 copies) of any article printed. Prices for these will be quoted upon request.

Address: Reprints,
Petroleum Refiner,
Box 2608
Houston 1, Texas

New Equipment . . .

ignited. This blaze was put out in less than 20 seconds with the 15-pound hand model.

In dry chemical fire fighting, an extremely fine powder is blown over the burning area. Heat from the fire causes a chemical reaction which releases a harmless, inert gas at an expansion ratio of 1,100-to-1 at 501 F. The expansion ratio increases further in proportion to the heat of the fire. The gas released smothers the fire almost instantly.

Especially well adapted to oil and gas fires, the extinguisher is safe for electrical fires also because it is a non-conductor. The chemical does not cake, freeze or deteriorate, and its fire-killing gas is harmless to humans and animals, even in confined places. Fire King Corp.

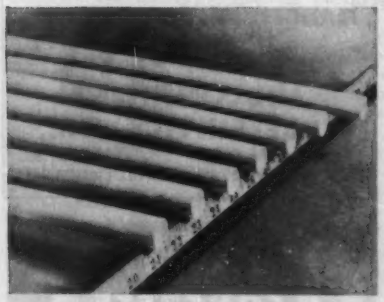
Circle E21 green card, last page

Requirements for Coatings Found in 204-Page Manual

The Foster Technical and Sales departments, after making a thorough study, have compiled complete technical information to assist industry in the proper adaption and application of mastics, flashing compounds, adhesives and surface coatings. This information is in a 208-page manual covering practically every requirement for insulation protection.

All of the information has been classified as to industry usage, i.e., commercial, power, process, cold storage and marine. The material used in the industry has also been classified into categories: mastics, adhesives, joint sealers and flashing compounds, surface coatings and sealers The complete publication includes general information and product data for each category as well as specific applications, product information, individual specific specifications and complete application drawings. Benjamin Foster Co.

Circle E22 green card, last page

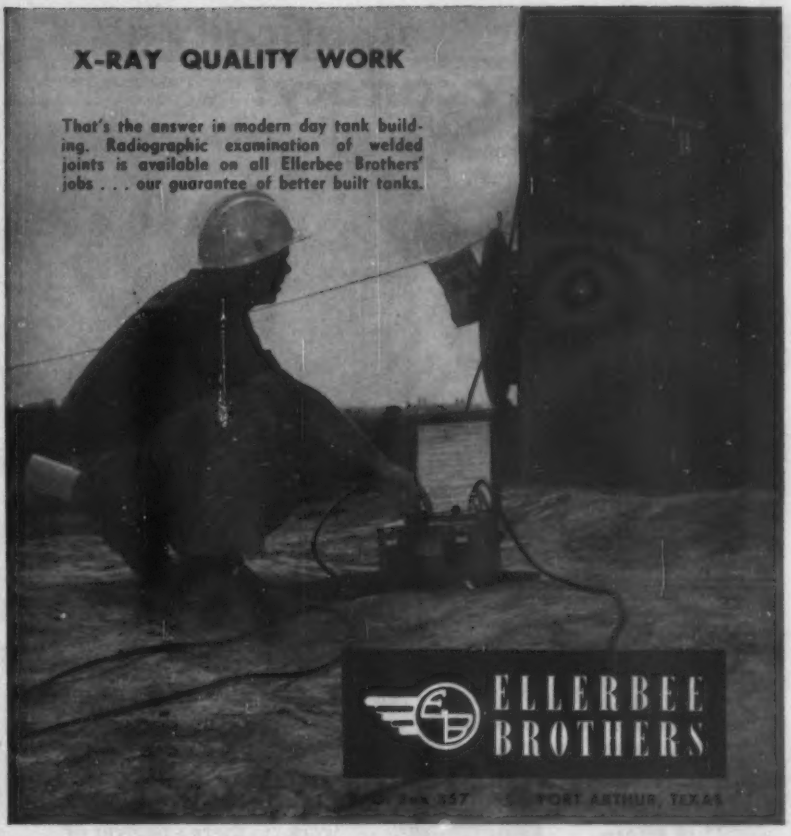


Heat Exchanger Material Proved in Missile Cone

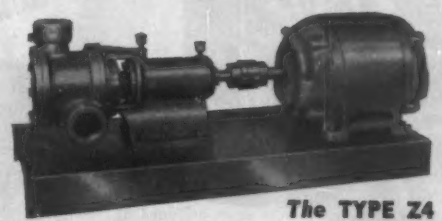
High temperature heat exchangers may soon use tubing of Pyroceram, a new crystalline material that has recently been tested for use as a guided missile nose cone.

Commercial production of tubing and plate to be sold under the Pyroceram trademark has begun. Pyroceram tubing, with excellent thermal shock qualities, is currently undergoing tests in heat exchangers.

Current production schedules on a continuous melting tank call for Pyroceram


X-RAY QUALITY WORK
That's the answer in modern day tank building. Radiographic examination of welded joints is available on all Ellerbee Brothers' jobs . . . our guarantee of better built tanks.
ELLERBEE BROTHERS
PORT ARTHUR, TEXAS

Is the Handling of
LIQUEFIED PETROLEUM GASES, REFRIGERANTS and other LIGHT NON-VISCOUS LIQUIDS
Bothersome to You?
IT NEED NOT BE



The TYPE Z4
AURORA® APCO *Process* PUMPS

WRITE for BULLETIN 111-ZA

AURORA Always PUMPS

You are urged to get acquainted with this complete answer to many of the most difficult pumping tasks of modern industry. The characteristics of the most advanced turbine-type pump, the APCO, combine with special new design features, special metals where required to insure SURE RESULTS. May we tell you more?

DISTRIBUTORS IN PRINCIPAL CITIES

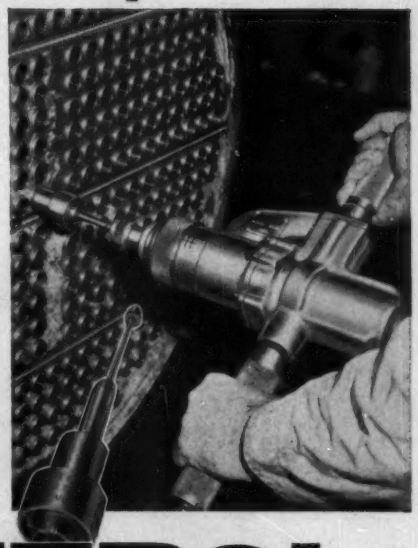
AURORA PUMP DIVISION
THE NEW YORK AIR BRAKE COMPANY
84 LOUCKS STREET • AURORA • ILLINOIS
EXPORT DEPARTMENT — Aurora, Illinois — Cable Address "NYABINT"

For more data on advertised products, use Readers' Service Cards, last page.

Roll tubes automatically to uniform accuracy!

AIRETROL is a great new advancement in automatically controlled tube rolling. It combines a powerful pneumatic motor drive and precision control into one compact, lightweight, easy-to-operate tool.

Simple adjustment sets AIRETROL to correct expansion. Torque sensing cam controls expansion automatically to .001 of an inch.



NEW

AIRETROL

TUBE EXPANSION CONTROL

EASY TO OPERATE...

QUICKLY ADJUSTED FOR ROLLING TUBES ¼" TO 1½" I. D.

AVAILABLE SPEEDS: 700, 550 AND 400 RPM

AIRETROL eliminates guesswork . . . there's no over or under expansion. Every tube joint can be rolled to maximum tightness and holding strength, assuring longer service.

FASTER ROLLING... LESS OPERATOR FATIGUE

PNEUMATICALLY OPERATED

AIRETROL's cushioned shut-off prevents sudden shock or strain on operator. Entire cycle is smooth, fast, easy. Average operator can roll up to 12 tubes per minute with AIRETROL.

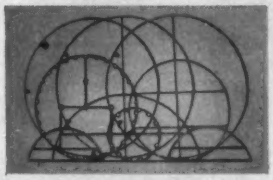
Send for illustrated and descriptive Bulletin No. 64 on AIRETROL.

BRANCH OFFICES: New York, Chicago, Tulsa, Philadelphia, Houston, Baton Rouge.
REPRESENTATIVES in principal cities of U.S.A., Canada, Mexico, South America, England, Puerto Rico, Italy, Japan, Hawaii.
EUROPEAN PLANT: Vlaardingen, The Netherlands.
CANADIAN PLANT: Brantford, Ont.

AIRETOOL
MANUFACTURING COMPANY
SPRINGFIELD, OHIO

GASKETS

For Every Purpose



HEAT EXCHANGER GASKETS

Made in any size or shape needed in double jacket type. Also cut from solid metal or sheet packing. Write for Bulletin 564.

CORRUGATED METAL GASKETS

Plain or jacketed type. Made of ingot iron, aluminum, stainless steel, copper, brass, nickel and monel in all sizes and shapes. Write for Bulletin 565.

PROMPT DELIVERIES

CHICAGO-WILCOX MFG. CO.
7719 So. Avalon Ave., Chicago 19, Ill.

STEEL PIPE and TUBING

• CARBON MOLY CHROME MOLY
• STAINLESS • CARBON

FLANGES, VALVES & FITTINGS

• Carbon • Alloy • Stainless Hollow Forgings
All Sizes – Write For Stock List

MIDCONTINENT TUBE SERVICE, INC.
2120 LEE ST. EVANSTON, ILL.
Phone: DAvis 8-4030 TWX Evanston 2276

GUNITE

Since 1915
CONCRETE
SAND AND CEMENT
"Placed by Air"

GUNITE
BLO-CRETE **WET-CRETE**
LINING, ENCASING, FIREPROOFING, REPAIRING

Send for our new bulletin No. 20 of actual photographs, information and detailed specifications.

GUNITE CONCRETE & CONST. CO.
1301 WOODSWETHER RD., KANSAS CITY 5, MO.
2016 W. Walnut St., Chicago 12, Ill.
1004 Market St., St. Louis 1, Mo.
3206 Houston Ave., Houston 9, Texas
1136 W. Orangethorpe, Fullerton, Calif.
Milwaukee—Twin Cities—Denver—New Orleans

For more data on advertised products, use Readers' Service Cards, last page.

tubing with various diameters and lengths up to 10 feet.

A thin-walled tube of the material, developed for use in high temperature heat exchangers, can be heated to 1300 F. and then plunged into ice water with no effect.

Because of its resistance to thermal shock and its high strength, tubing of Pyroceram in heat exchangers will allow higher temperature differentials, wider selection of fluids to be cooled and higher cooling rates than would tubing of glass. Corning Glass Works.

Circle E23 green card, last page

Guide to Specification Writing Given in Catalog

Detailed engineering data and performance characteristics, and a guide to writing specifications, are sections of a centrifugal compressor catalog being offered.

This 64-page, illustrated catalog includes an introduction to centrifugal compressor features and applications and sections on horizontally and vertically split compressors. A general section deals with compressor fundamentals, parts, drivers, engineering data and specifications.

The part describing horizontally split centrifugal compressors outlines models and advantages of these units, plus internal construction features, and dimensions and weights. Another section explaining vertically split centrifugal compressors gives detailed information about the case, rotor, impellers, diaphragms and guide vanes of these products.

The final section is devoted to seals, testing and drivers for centrifugal compressors, including details about gas turbines. Engineering and performance charts and equations appear in this section along with a guide to writing specifications and considerable application data. Clark Bros. Co.

Circle E24 green card, last page

Bulletin Describes Three Dry Desiccant Systems

A technical service bulletin discusses the advantages and disadvantages of three desiccant systems: dry desiccants, Diethylene Glycol and Triethylene Glycol.

Economic and operating factors for these systems are given. Cost figures for operating a dry desiccant plant per million standard cubic feet of gas are also included. Nitrogen Division, Allied Chemical & Dye Corp.

Circle E25 green card, last page

Wall-Mounted Feeder Pumps Directly From Drums

A compact, redesigned version of the economical wall-mounted Diaphragm Feeder, Model 19130, is the subject of a recently issued bulletin. The new bulletin features explanatory text, photographs, and dimensional drawing indicating that this streamlined unit retains the tested advantages of the former model while taking up less than half the space.

The feeder pumps directly from carboys, drums, and other shipping containers without dangerous transfer to storage units, and is unaffected by most corrosive chemicals. Pumping rates, from 0.8 to 8.0 gallons per day, are adjusted by varying the length and frequency of the stroke. Accuracy is held within plus or minus 5 percent over a 5-to-1 range. Proportioneers, Inc.

Circle E26 green card, last page

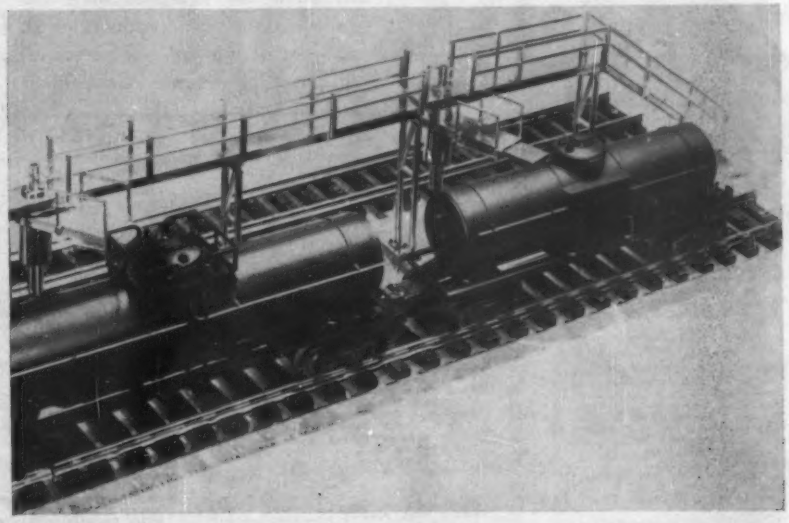
Rotating Deck Serves Cars On Both Sides of Rack

A new prefabricated rack enables an operator to reach any size or type car quickly, easily and with safety. The rack is prefabricated from hot rolled structural sections for bolting together in the field.

The gap between the elevated walkway and the tank cars is bridged by a rotating deck which will rotate through an arc of 240 degrees to serve cars on both sides of the rack. The rotating deck also raises and lowers by a simple mechanism, making it adaptable to all height cars. Because of the rotating characteristics, accurate tank car spottings are not required, and a retractable extension to the rotating deck will service cars of all types of construction. Houston Engineering & Mfg. Co.

Circle E27 green card, last page

New Equipment . . .



BLINDS • SPACER RINGS • TEMPORARY and LINE STRAINERS • PIVOT FLANGES

MAC-IRON is the name on eight authoritative pages in the 1958 Refinery Catalog. You'll find specifications, descriptions, and data on equipment designed and constructed to function with extreme efficiency.

As specialists to the Petro-Chemical Engineering Field for many years *MAC-IRON* has developed skills and facilities which make possible a degree of design and production service seldom equalled. In the event of an emergency or tight schedule, *phone Sandusky MAin 6-3712* for immediate attention to your problem.

Refer to our pages and listings in Refinery Catalog or write direct for MAC-IRON CATALOG A-7. Your inquiry will receive prompt attention. Specific engineering data formulated on request.

"IF YOU USE PUMPS
You need MAC-IRON Strainers"

SANDUSKY MAC-IRON OHIO
ESTABLISHED 1901

THE MACK IRON WORKS COMPANY
121 WARREN ST., SANDUSKY, OHIO

Advertisers in This Issue

PETROLEUM REFINER, May, 1958

*The asterisk preceding name of advertiser indicates that detailed data on products and services of the firm will be found in The 1958 Refinery Catalog.

A

The Aber Company....281
*Aerovent Fan Co.
Large Propeller Division....378b
*The Air Preheater Corp....290
*Airetool Manufacturing Co....390a
Allied Chemical-Nitrogen Division....59
Allied Chemical & Dye Corp....93, 95, 284, 362
*Allis-Chalmers Mfg. Co....9
The Allpax Co....356
*Aluminum Company of America....297
Amercoat Corp....261
*American Air Liquide....115
American Bitumuls & Asphalt Co....383
American Brake Shoe Co....96
*American Brass Co....246
American Cyanamid Company
Refinery Chemicals Department....62
American Petroleum Institute....260
Amoco Chemicals Corp....125
Armstrong Machine Works....43
The Atlantic Refining Co....25
Atlas Powder Co....143
*Aurora Pump Division
The New York Air Brake Co....389b
*Autoclave Engineers, Inc....320
Avondale Marine Ways, Inc....363a

B

*The Babcock & Wilcox Co....337
*Badger Manufacturing Co....56-57
*Baldwin-Hill Co....26
Barksdale Valves....371a
Barrett Manufacturing Co....386a
*The Belmont Packing & Rubber Co....322
Betz Laboratories, Inc....299
The Bird-Archer Co....381
*Blaw-Knox Co....30, 78
Bonney Forge & Tool Works....353
*Bopp & Ruether S. m. b. H....360a
*Borden Metal Products Co....241
*Bowser, Inc....60
*Bridgeport Brass Co....51
The Bristol Co....110-111
*British Ermeto Corp. Ltd....72-Db
*Buell Engineering Co....128
*Buffalo-Eclipse Corp....336
Buffalo Hydraulics Division
Houdaille Industries, Inc....348
Burrell Corp....386

C

*The Cape Asbestos Co, Ltd....72
*C. O. Carlson, Inc....34
*The Carpenter Steel Co....345
*Carrier Corp....302-303
Carter-Waters Corp....387a
Catalytic Construction Co....11
*Catawissa Valve & Fittings Co....319
Cathodic Corrosion Control Ltd....72-Fa
Centrifix Corp....354
The Chapman Valve Mfg. Co....256-257
*Chemical Construction Corp....145
*Chicago-Wilcox Mfg. Co....390b
*Chikaan Co....251
*Clark Bros. Co.
One of the Dresser Industries....69
Classified Advertising....372
*The Cleveland Wire Cloth & Mfg. Co....264
*Clyde Tube Forgings Limited....72-G
The Colorado Fuel & Iron Corp....341
Columbia-Geneva Steel Division
United States Steel Corp....82
Combustion Engineering, Inc....44-45
Cooper Alloy Corp....330
*The Cooper-Bessemer Corp....122
*Coppus Engineering Corp....73
Crane Company....243
Crane Packing Co....286
Crawford Fitting Co....346
Crescent Insulated Wire & Cable Co....371b
Crouse-Hinds Co....348

D

Dameron Enterprises, Inc....389b
Davison Chemical Company
Division W. R. Grace & Co....315
De Laval Steam Turbine Co....91
Dempster Brothers....94
DeZurik Corp....367a
*Dorr-Oliver, Inc....29
Dowell Incorporated....249
*Downingtown Iron Works, Inc.
Division Pressed Steel Tank Co....370
*Dresser Industries, Inc....69, 121
*The Duson Co....361
E. I. du Pont de Nemours & Co....105-106, 134, 307-308
*Duralmetallic Corp....388b

E

The Eagle-Picher Co....90
Electro-Alloys Division
American Brake Shoe Co....96
Ellerbee Brothers....389a
*Elliott Co....108
Emco Brass Manufacturing Co. Ltd....72-Mb
*Enjay Company....20
Ethyl Corp....136-137
Evershed & Vignoles Ltd....72-C

F

Ferro Corp....355
*Fibreboard Paper Products Corp....75
*Fisher Governor Co....49
*Flexitallic Gasket Co....254
Flexonics Corp....316
The Fiori Pipe Co....71
*Food Machinery & Chemical Corp....70, 338
*Forge & Fittings Division
H. K. Porter Company, Inc....270
*Foster Wheeler Corp....85, 283
The Foxboro Co....35-40

G

Gardner-Denver Co....126
*The Garlock Packing Co....8
General Chemical Division
Allied Chemical & Dye Corp....93, 362
*General Electric Co....252-253
General Welding Works, Inc....388a
The Globe Co....384
Claud S. Gordon Co....288
W. R. Grace & Co....315
*Graham Manufacturing Co....262
*Graver Tank & Mfg. Co....6
A. P. Green Fire Brick Co....65
*Grinnell Company, Inc....138
*The Griscom-Russell Co....80
*The Gulf Publishing Co....365b, 373b
Gunite Concrete & Const. Co....390d

H

*Hamer Valves, Inc....385
*Hammond Iron Works....117
*Harbison-Walker
Refractories Co....294-295
*The Harshaw Chemical Co....28
*Hartzell Propeller Fan Co....366
Head Wrightson & Co. Ltd....72-A
*Hendrick Manufacturing Co....363
*Hewitt-Robins....364
*Homestead Valve Mfg. Co....27
Houdaille Industries, Inc....348
Houdry Process Corp....335
*Hudson Engineering Corp....375

I

I-T-E Circuit Breaker Co.
Switchgear Division....68
*Ingersoll-Rand Co....52-53
International Business
Machines Corp....118
The International Nickel Co....112, 245

J

*Jerguson Gage & Valve Co....260
*Johns-Manville Corp....116, 265
Jones & Laughlin Supply Division....10

K

Kano Laboratories....363e
*The M. W. Kellogg Co....106-109
Kinney Manufacturing Division
The New York Air Brake Co....331
*Koch Engineering Co....III Cover
Koppers Company, Inc....90
Koven Fabricators....360

L

*Lake & Elliot Ltd....72-Ma
Langley Alloys Ltd....72-Hb
Lapp Insulator Co....74
Lawrence Pumps, Inc....343
Lenape Hydraulic Pressing & Forging Co....340
F. B. Leopold Co....313
LimiTorque Corp....16
Lukens Steel Co....332-333
*The Lummus Co....276
The Lunkenheimer Co....63

M

*The Mack Iron Works Co....391
*Magnetrol, Inc....367b
Maintenance Engineering Corp....379
Manning, Maxwell & Moore, Inc....144
*Jas. P. Marsh Corp....351
*Mason-Neilan Division
Worthington Corp....266-267
Arthur G. McKee & Co....IV Cover
*The Mercoid Corp....248
*Metal Propellers Ltd....72Ha
Midcontinent Tube Service, Inc....390c
*Mine Safety Appliances Co....83
Minneapolis-Honeywell....33, 287
Missouri Boiler Works Co.
Division Nooter Corp....131
*W. K. Mitchell & Co....79
*Mixing Equipment Co....132
Modern Welding Co....301
*N. V. Motorenfabriek THOMASSEN....72B
Mutual Chromium Chemicals
Solvay Process Division
Allied Chemical & Dye Corp....86

N

*National Airoil Burner Co....330
National Tube Division
United States Steel Corp....82
*New England Tank & Tower Co....300
*The New York Air Brake Co....331, 389b
W. H. Nicholson & Co....318
*The C. W. Nofsinger Co....377
*Nooter Corp....131, 259
James North Export Ltd....72-Fb
*Norton Co....43

O

*OTM Corporation....279
*Oakite Products, Inc....305
The Ohio Injector Co....54
*The Ohio Steel Foundry Co....65
*Oil Well Supply Division
United States Steel Corp....7
Okadee Co....309
*Orbit Valve Co....100-101

P

*Pabco Industrial Insulations Division
Fibreboard Paper Products Corp....75
*Pacific Pumps, Inc....121
Pacific Valves, Inc....384
Palmer Thermometers, Inc....124
The Patterson Foundry & Machine Co.
Subsidiary of Ferro Corp....355
Tod Pazdral Pipeline Specialties....327
Peerless Manufacturing Co....87
*Peerless Pump Division
Food Machinery & Chemical Corp....70
*Penberthy Manufacturing Co.
Division Buffalo-Eclipse Corp....336
Pennsalt of Washington Division
Pennsalt Chemicals Corp....350
Pennsylvania Flexible Metallic
Tubing Co....314
Perkin-Elmer Corp....352
*The Permutit Co., Division of
Pfaudler Permutit Co....347, 359
*Petroco Division
Petrolite Corp....88
*Petro-Chem Development Co....104
*The Pfaudler Co., Division of
Pfaudler Permutit Inc....347, 359
*Phelps Dodge Copper
Products Corp....14-15
Philadelphia Gear Works, Inc....16
Pilbrico Co....369a
*H. K. Porter Company, Inc....270
*Posey Iron Works, Inc....373a
The Wm. Powell Co....110
*Pressed Steel Tank Co....370
Procon Incorporated....323
*Proportioneers, Inc., Division
S-I-F Industries, Inc....II Cover
Puget Sound Fabricators, Inc....360b
Purolator Products, Inc....388a
The Pyle-National Co....17
The Quaker Oats Co....320

R

Ready Cool, Inc....328
Redhaugh Iron & Steel Co. Ltd....72-Da
*The Refinery Catalog....146-147
Richard C. Remmey & Son Co....113
The Ridge Tool Co....365e
*Rochester Manufacturing Co....357
W. S. Rockwell Co....247, 387b
*Rockwell Manufacturing Co....88-89
*Rockwood Sprinkler Co....61, 285, 317
Russell Engineering Corp....21

S

*Schutte & Koerting Co....360c
*Selas Corporation of America....24
Serck Tubes Limited....72-E
Service Foundry Division
Avondale Marine Ways, Inc....363a
Shand & Jura Co....32
*Shaw-Petrie Ltd....72-G
*Sier-Bath Gear & Pump Co....382
*M. B. Skinner Co....388d
*Nowery J. Smith Co....387c
Smithco Engineering, Inc....283
Solvay Process Division
Allied Chemical & Dye Corp....85, 284
Sparkler Manufacturing Co....325
Speedline Stainless Steel Division
Horace T. Potts Co....129
Standard Oil Company of California....13
Standard Oil Company (New Jersey)....376
Stauffer Chemical Co....55
*Strahman Valves, Inc....292
*Stratford Engineering Corp....58
*Sun Shipbuilding & Dry Dock Co....342
Sunvic Controls Ltd....72-J
Switchgear Division
I-T-E Circuit Breaker Co....68

T

Tai Bending Equipment, Inc....373c
*Tangyes Limited....72-K
*Taylor Instrument Companies....102
Tellepsen Petro-Chem Constructors....31
*Tennessee Corp....363b
*The Terry Steam Turbine Co....64
The Texas Company....41
Texas Instruments, Inc....296
Texas Metal Fabricating Co....96
*Thermal Research & Engr. Corp....268
*N. V. Motorenfabriek
THOMASSEN....72-B
The Timken Roller Bearing Co....12
*Tretolite Company
Division Petrolite Corp....114
Truland Chemical Co....306b
Trusees Laboratories, Ltd....321

U

Union Wire Rope Corp....84
United States Gasket Co....344
United States Pipe & Foundry Co....76-77
*United States Rubber Co....239
United States Steel Corp....7, 82
United States Steel Export Co....82
United States Steel Supply Division
United States Steel Corp....82
*The United States Stoneware Co....31
*Universal Atlas Cement Co....107
Universal Oil Products Co....18-19, 50

V

*Henry Vogt Machine Co....123
Vokes Geospring Ltd....72-L
*J. H. H. Voss Co....386b

W

*W-S Fittings Division
H. K. Porter Company, Inc....270
Wagner Electric Corp....92
Walsh Refractories Corp....324
Walworth Co....97
Warren Petroleum Corp....310
Washington Aluminum Co....365a
West Instrument Corp....250
Western Supply Co....87
Westinghouse Electric Corp....22-23
Westvaco Mineral Products Division
Food Machinery & Chemical Corp....70
Wickwire Spencer Steel Division
The Colorado Fuel & Iron Corp....341
*The Gustav Wiedeke Co....298
A. R. Wilfley & Sons, Inc....47
T. D. Williamson, Inc....291
*Thomas C. Wilson, Inc....378a
Wisconsin Protective Coating Co....280
*Wolverine Tube Division
Calumet & Hecla, Inc....271-274
Worcester Valve Co....326
*Worthington Corp. 139-142, 266-267, 306a

Y

*Yarnall-Waring Co....42
*Otto H. York Co....127
*Yuba Consolidated Industries, Ltd....46

Z

*Zallea Brothers....289
*John Zink Co....275

use these

Reader's Service Cards for More Information

Circle code number for more data on "New Equipment" editorial items

Circle page number for more information on ADVERTISED products

PETROLEUM REFINER Readers' Service Card — **May, 1958, Issue***

EDITORIAL ITEMS—Circle code numbers on which more information desired:

E1 E16	E2 E17	E3 E18	E4 E19	E5 E20	E6 E21	E7 E22	E8 E23	E9 E24	E10 E25	E11 E26	E12 E27	E13	E14	E15

ADVERTISEMENTS—Circle page number of ad for more products information:

2	6	7	8	9	10	11	12	13	14	13	16	17	18	19	20	21	22	23	24
25	26	27	28	29	30	31	32	33	34	41	42	43	44	45	46	47	48	49	50
51	52	53	54	55	56	57	58	59	60	61	62	63	64	65	66	67	68	69	70
71	72	72A	72B	72C	72Da	72Db	72E	72Fa	72Fb	72G	72Ha	72Hb	72J	72K	72L	72Ma	72Mb	73	74
75	76	77	78	79	80	81	82	83	84	85	86	87	88	89	90	91	92	93	94
95	96	97	98	99	100	101	102	103	104	105	106	107	108	109	110	111	112	113	114
115	116	117	118	119	120	121	122	123	124	125	126	127	128	131	132	134	135	136	137
138	139	140	141	142	143	144	145	146	147	239	241	243	245	246	247	248	249	250	251
252	253	254	256	257	259	260	261	262	263	264	265	266	267	268	269	270	271	272	273
274	275	276	279	280	281	283	284	285	286	287	288	289	290	291	292	293	294	295	296
297	298	299	300	301	302	303	304	305	306	307	308	309	310	313	314	315	316	317	318
319	320	321	322	323	324	325	326	327	328	329	330	331	332	333	335	336	337	338	339
340	341	342	343	344	345	346	347	348	349	350	351	352	353	354	355	356	357	359	360
361	362	363	364	365	366	367	368	369	370	371	373	375	376	377	378a	378b	379	380	381
382	383	384	385	386a	386b	387a	387b	387c	388a	388b	388c	388d	389a	389b	390a	390b	390c	390d	391

Name (Please Print)_____

Company_____ Position_____

Address_____

*MAY ISSUE CARD EXPIRES AUGUST 15, 1958 — Check Square for Extra Card ☐

Postage Will be Paid by Gulf Publishing Company

No Postage Stamp Necessary If Mailed in the United States

BUSINESS REPLY CARD

First Class Permit No. 7 (Sec. 34.9, P. L. & R.), Houston, Texas

Petroleum **Refiner**

BOX 2608

HOUSTON 1, TEXAS U.S.A.

Quick–Easy

Use these cards to get quick information about New Equipment, Catalogs and literature mentioned in the Editorial columns or advertised in PR

Who's Your Man?

(see Page 240)

"GREATEST CONTRIBUTION" Nominee

I nominate_____
for a listing in PETROLEUM REFINER'S Honor Pages to be presented in its Oil Centennial Edition, January 1959 as being the man who has made the greatest contribution to the Oil, Gas and Petrochemical Processing Industry.

(Signed)_____

(Address)_____

(Tear out card and mail after writing in your nomination. If you wish to elaborate, please use an envelope with supporting facts attached to the card.)

use these

Reader's Service Cards for More Information

Postage Will be Paid by Gulf Publishing Company

No Postage Stamp Necessary If Mailed in the United States

BUSINESS REPLY CARD
First Class Permit No. 7 (Sec. 34.9, P. L. & R.), Houston, Texas

Petroleum **Refiner**

BOX 2608

HOUSTON 1, TEXAS U.S.A.

PETROLEUM REFINER Readers' Service Card — **May, 1958, Issue***

EDITORIAL ITEMS—Circle code numbers on which more information desired:

E1	E2	E3	E4	E5	E6	E7	E8	E9	E10	E11	E12	E13	E14	E15
E16	E17	E18	E19	E20	E21	E22	E23	E24	E25	E26	E27			

ADVERTISEMENTS—Circle page number of ad for more products information:

2	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20	21	22	23	24
25	26	27	28	29	30	31	32	33	34	41	42	43	44	45	46	47	48	49	50
51	52	53	54	55	56	57	58	59	60	61	62	63	64	65	66	67	68	69	70
71	73	72A	72B	72C	72Da	72Db	72E	72Fa	72Fb	72G	72Ha	72Hb	72J	72K	72L	72Ma	72Mb	73	74
75	76	77	78	79	80	81	82	83	84	85	86	87	88	89	90	91	92	93	94
95	96	97	98	99	100	101	102	103	104	105	106	107	108	109	110	111	112	113	114
115	116	117	118	119	120	121	122	123	124	125	126	127	128	131	132	134	135	136	137
138	139	140	141	142	143	144	145	146	147	239	241	243	245	246	247	248	249	250	251
252	253	254	256	257	259	260	261	262	263	264	265	266	267	268	269	270	271	272	273
274	275	276	279	280	281	283	284	285	286	287	288	289	290	291	292	293	294	295	296
297	298	299	300	301	302	303	304	305	306	307	308	309	310	313	314	315	316	317	318
319	320	321	322	323	324	325	326	327	328	329	330	331	332	333	335	336	337	338	339
340	341	342	343	344	345	346	347	348	349	350	351	352	353	354	355	356	357	359	360
361	362	363	364	365	366	367	368	369	370	371	373	375	376	377	378a	378b	379	380	381
382	383	384	385	386a	386b	387a	387b	387c	388a	388b	388c	388d	389a	389b	390a	390b	390c	390d	391

Name (Please Print)_____

Company_____ Position_____

Address_____

*MAY ISSUE CARD EXPIRES AUGUST 15, 1958 — Check Square for Extra Card ☐

Postage Will be Paid by Gulf Publishing Company

No Postage Stamp Necessary If Mailed in the United States

BUSINESS REPLY CARD
First Class Permit No. 7 (Sec. 34.9, P. L. & R.), Houston, Texas

PETROLEUM REFINER

BOX 2608

HOUSTON 1, TEXAS U.S.A.

Quick–Easy

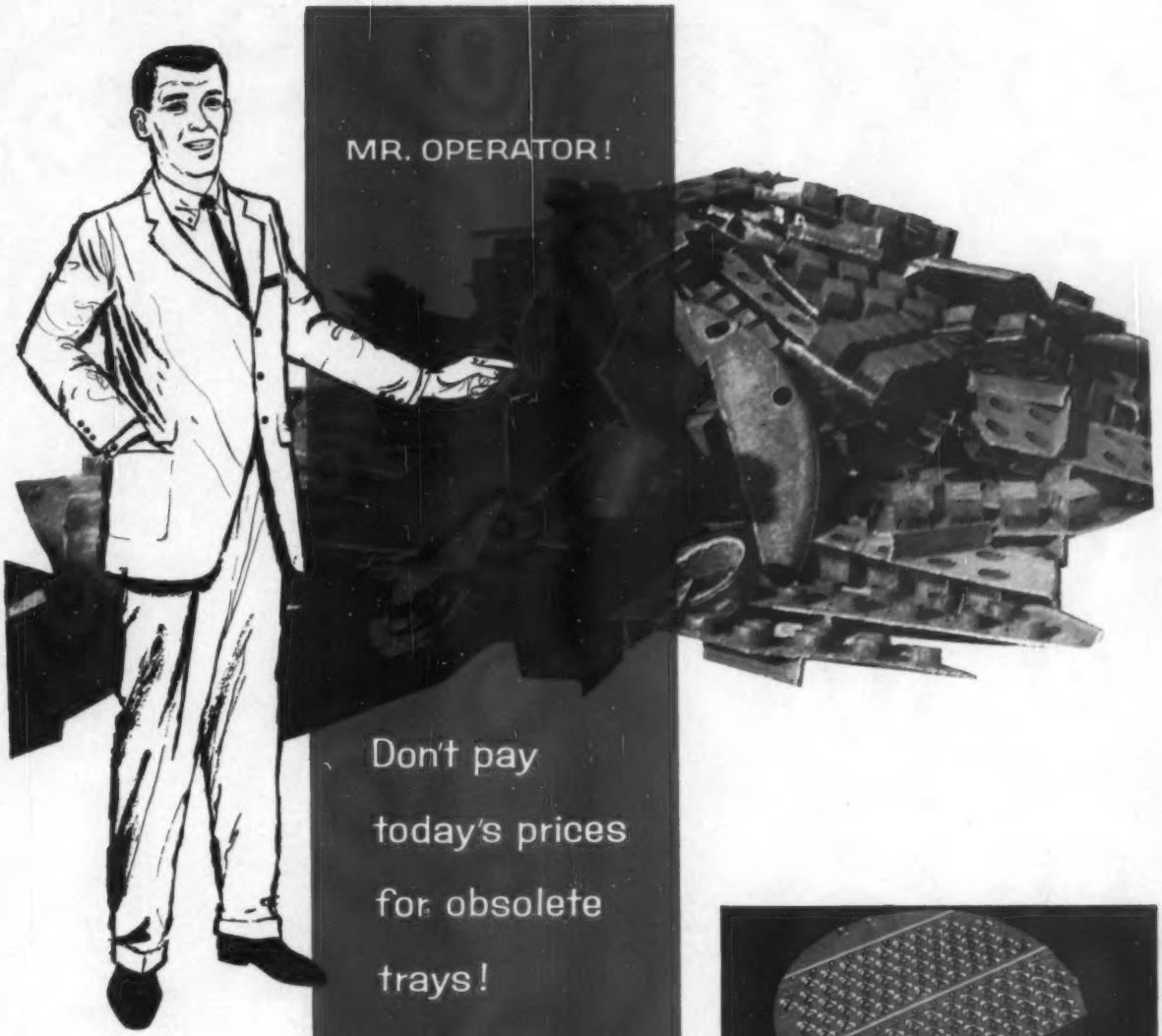
Use these cards to get quick information about New Equipment, Catalogs and literature mentioned in the Editorial columns or advertised in PR

Circle code number for more data on "New Equipment" editorial items

Circle page number for more information on ADVERTISED products

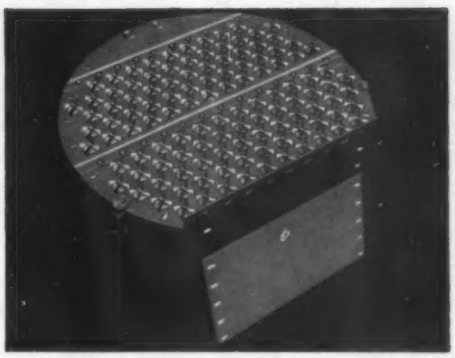
Nominate Your Man

(Use this card after reading the bottom of Page 240 in this issue)



The need for higher capacities resulted in junking the above — after approximately two years of service! Installing *lower-priced Flexitrays in the first place* would have prevented this expensive — and unnecessary — replacement!

Where higher capacities are a necessity . . . ***Flexitrays are a necessity!*** Don't be caught with "yesterday's" equipment today — specify modern Koch Flexitrays!



Low-price Flexitray — for high capacity and extreme flexibility.

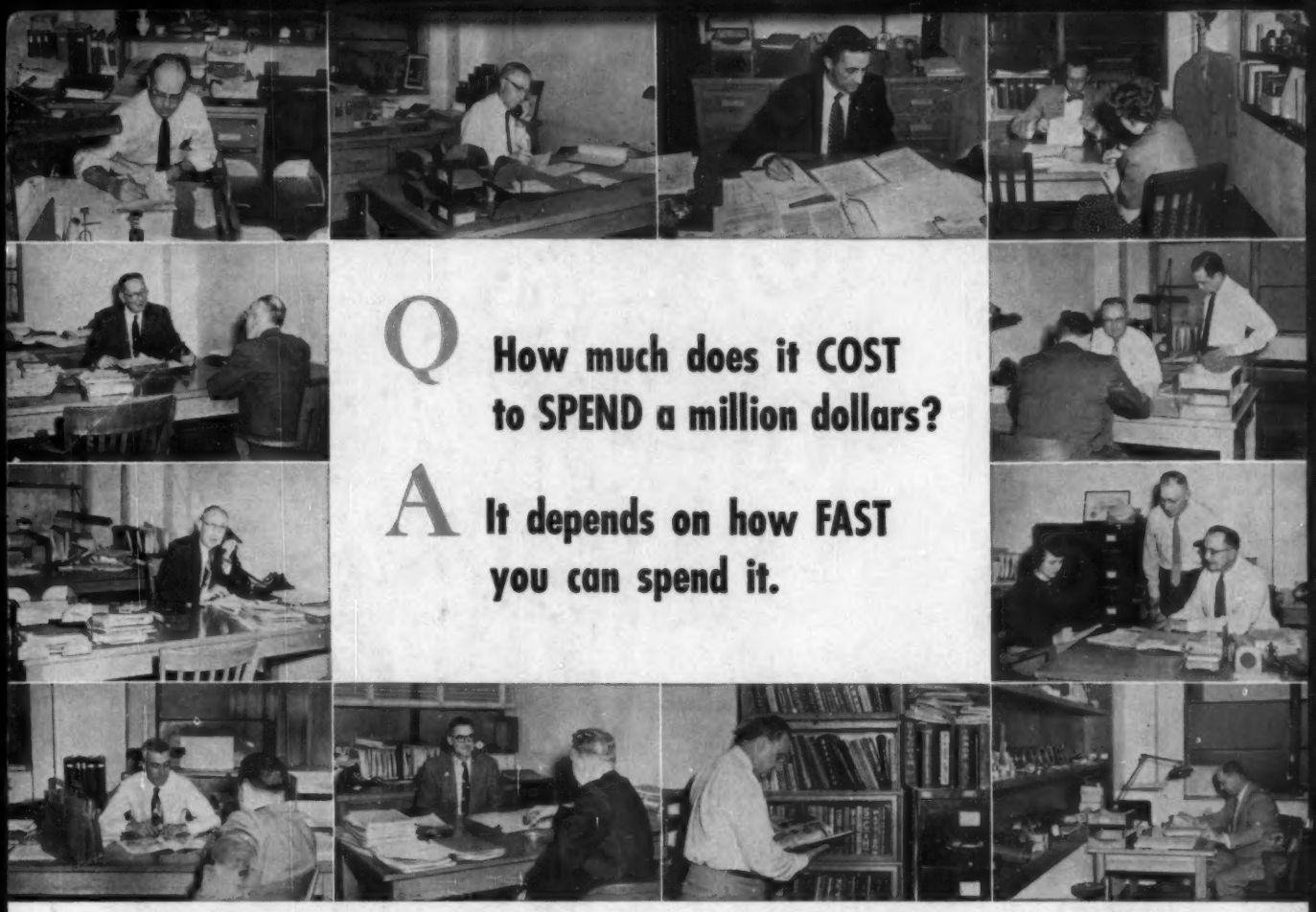
Representatives:

Eastern Representative: F. J. McConnell, 60 E. 42nd St., New York 17, New York
Tulsa, Oklahoma Representative: W. C. Myers Company, Wright Building
Houston, Texas Representative: Alpha Engineering Company, P. O. Box 12371
Pittsburgh, Pennsylvania Representative: D. D. Foster Company, 501 Alcoa Building
West Coast Representative: Jacobs Engineering Company, Pasadena: RYan 1-9373; Oakland, TEmplebar 2-5391
Illinois Representative: M. B. Fisher, 1521 Courtland Avenue, Park Ridge, Illinois
St. Louis, Missouri Representative: Sample Brothers, STerling 1-7941

KOCH

ENGINEERING COMPANY, INC.
321 West Douglas Avenue, Wichita 2, Kansas

Continuing progress through research



Q How much does it COST to SPEND a million dollars?

A It depends on how FAST you can spend it.

McKee "spending specialists" can save you time and money on your new plant

THESE men, and dozens more like them at McKee, are experts in the art of spending *your* money *fast.* And that's to your advantage when you do business with McKee.

One of the not inconsiderable costs of engineering and construction of your new petroleum refinery, petro-chemical or chemical plant lies in the paper work and man-hours it takes to specify, select, purchase, expedite and inspect the material and equipment for the project.

McKee purchasing experts know how to get the *right* material, from the *right* source, at the *right* price, on the job at the *right* time. They know what they want and where to get it, anywhere in the world—how to use nearest sources to cut shipping costs—how to time deliveries for a minimum of handling expense at the site.

To you, this means lower over-all cost. But, more important, fast, efficient purchasing and expediting helps transform your new plant expense into an operating, profit-making investment at the earliest possible date.

McKee
ENGINEERING & CONSTRUCTION Services

Arthur G. McKee & Company • Engineers and Contractors
Headquarters: McKee Building • 2300 Chester Avenue • Cleveland 1, Ohio
Offices: New York, N. Y. • Union, New Jersey • Washington, D. C.
British Representatives of Metals Division: Head, Wrightson & Co., Limited
Canada: Arthur G. McKee & Company of Canada, Ltd., 372 Bay St., Toronto